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The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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The B.C.I.R.A. Report

The annual report of the Council of the British Cast Iron Research Association is being presented to members to-day. The progress reported is a matter of general interest, because the Association is a national body and, indeed, is the only research association exclusively devoted to founding and its allied problems. While the income does not reflect the increase that might be expected during a period of vastly improved business conditions within the industry, it is higher than at any previous time, and is now between fourteen and fifteen thousand pounds per annum. There should be no cessation of this expansion until this figure is about twenty-five thousand pounds, which must be considered a minimum for an industry of such importance and technical complexity. This would permit on an adequate scale the information bureau, a large corps of research workers and a development staff of experts able to apply the laboratory results directly to the industry, and see that any scientific knowledge available and needed is placed at its disposal. It is difficult for the small founder, the man who often has to work without any technical staff, to see that the data of which he can avail himself to-morrow are only being learned in the laboratory to-day, and that without this provision he would be handicapped, but it is not too much to say that within the past ten years the production of cast iron has been raised from the empirical, and there are signs that it may soon become completely scientific and controllable.

Among the changes taking place, the Rt. Hon. the Earl of Dudley, M.C., becomes President in succession to Major Freeth, whose energy and help has earned warm thanks. Among the forecasts for the future is the question of central premises which will, we hope, be pressed forward. We are familiar with other bodies of the same type where a bold policy has resulted in an accession of strength. Buildings in themselves, of course, do not have special significance, but in an organisation they facilitate planning of work in a way that makes for efficiency and form an external mark in which the industry can take pride. Their advertising value to users is considerable, for they form a concrete representation in their minds of the technical resources at the industry's disposal.

Cast Iron Failures Reduced

Just after the war there was a veritable spate of accidents due to the failure of large fly wheels. These accidents were of such a magnitude that they were invariably "front page" news for the local Press. From that time onwards there has been reported in diminishing volume, year by year, in the annual reports of the British Engine Boiler and Electrical Insurance Company, Limited, failures involving grey-iron castings. The last report, however, has not one single reference to such failures, and one might justifiably conclude that material made during the last decade is infinitely more reliable than heretofore. This may be due to either better inspection by the purchaser or improved practice on the part of the foundry executive. The absence of "interesting" failures stresses the point that the factor of safety as normally calculated by engineering designers is well in excess of the duty imposed upon cast iron. There is a demand—and a Paper by Mr. Matthew Russell, presented elsewhere in this issue is a typical example of this—by a section of the foundry industry that engineers should carefully consider the reduction of sections in view of the enhanced properties now to be expected from cast iron. In this effort, however, a word of warning seems opportune. In many engineering assemblies the property of rigidity—not necessarily strength—is of paramount importance, and to ensure a maximum of rigidity, mass is an essential. It is obvious that industries competing with foundry products are falling into this trap, and the makers of cast iron can well afford to await the final judgment of the user. For many applications a bend is more noxious than a break, whilst springiness in the structure is equally fatal to the production of dimensionally-accurate components. These statements must not act as a deterrent to make sections lighter where this can be done with no sacrifice of essential strength. Indeed, such efforts are commendable and must be instituted wherever possible. The time is obviously overdue for the majority of engineers to take stock of the potentialities of cast iron in the light of its improved properties consequent upon the better understanding of the fundaments of foundry metallurgy. Foundry owners could usefully direct the attention of buyers to these properties by offering in their quotations superior iron of guaranteed minimum strength related to section as an alternative, and at a higher price.

French Foundry Technical Association

FIFTEENTH ANNUAL CONGRESS AT LILLE

The fifteenth annual congress organised by the French Foundry Technical Association, which was to have been staged in June, will be held in Lille, under the patronage of the Under-Secretary of State for Technical Education, and under the Presidency of Mr. Maurice Werts (President of the Association), on November 13 and 14. Below is set out in detail the programme which has been arranged.

Friday, November 13

10 to 11.30 a.m.—Registration of delegates and distribution of badges at the Hotel Bellevue, 3 to 5, rue Jean Roisin.

12 noon.—Luncheon at the Hotel Bellevue. (Chairman, the Under-Secretary of State for Technical Education.) Award of the Association's medals for 1936.

3.0 p.m.—Opening session at the Salle des Ambassadeurs, Square Jussieu, Rue Nationale. (Chairman, Mr. H. Luc, Chief Inspector for Technical Education.) Presidential Address by Mr. Maurice Werts.

3.30 p.m.—The following Papers will be read and discussed. (Chairmen, Mr. A. Damour (Past-President) and Prof. Pisek (President of the Czecho-Slovakian Foundrymen's Association).)

(*a*) "Thermal Treatment of Cast Iron," by G. Delbart.

(*b*) "Cast Iron and Reactive Slags; Mixing and Churning; Application to Blast-Furnace and Cupola Practice," by Prof. F. L. C. Girardet.

(*c*) "Melting of High-Duty Cast Iron in the Cupola," by G. Henon.

(*d*) "Toughness of Cast Irons from Transverse Stress/Strain Curves," by G. L. Harbach. (British Exchange Paper.)

(*e*) "Influence of Atmospheric Moisture on Dry Moulds and on Naturally Bonded Cores," by B. Holman. (Czecho-Slovakian Exchange Paper.)

(*f*) "Reclamation, Preparation and Maintenance of Quality of Moulding Sands," by Lester B. Knight. (American Exchange Paper.)

(*g*) "Influence of Thermal Treatment below the Ac_1 on the Properties of Blackheart Malleable Iron," by M. Leroyer.

Evening free.

Saturday, November 14

9.30 a.m.—Visit to the Research Laboratories of the Institute of Applied Chemistry, 104, rue Jeanne d'Arc. The work of the laboratories will be explained by Prof. Chaudron and Prof. Lefebvre. Apperitifs will kindly be provided by the directors of the Institute.

12 noon.—Luncheon at the Hotel Bellevue. (Chairman, Mr. Ragey, Inspector for Technical Education.)

2 to 4.30 p.m.—The following Papers will be presented and discussed in the Salle des Ambassadeurs. (Chairmen, Mr. Chatelet, rector of the University of Lille, and Mr. J. Léonard, President of the Belgian Foundrymen's Association.)

(*a*) "The Bell Test for Gases Evolved by Aluminium," by Mr. Moreau.

(*b*) "Measurement of Hardness by Pellicules of Alumina," by Mr. Hache.

(*c*) "Aluminium-Magnesium Alloys for the Foundry," by Prof. G. Chaudron.

(*d*) "Fundamental Notions applied to the Development in Germany since 1933 of the Non-Ferrous Foundry Alloys," by Dr. W. Claus. (German Exchange Paper.)

(*e*) "Contribution to the Standardisation of Methods for Estimating the Total Carbon Content of Cast Iron," by Mr. Gevers. (Belgian Exchange Paper.)

4.30 p.m.—Closing session under the chairmanship of Mr. Ragey. Address by Mr. M. Werts.

5.0 p.m.—"Evolution of High-Duty Cast Irons," by R. P. Lemoine (assistant director of the Paris Foundry High School). (Chairman, Mr. M. Olivier, President of the French Foundry Employers' Federation.)

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

The Leaded Gunmetal Report

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I note in your issue of October 29 the report of my comments at Derby on the Non-Ferrous Sub-Committee's "Recommendations for Two Leaded Gunmetals." Apart from the points mentioned regarding less than 9 per cent. tin being preferable on the grounds of cheapness and less liability to "tin sweat" (7 per cent. being suggested), I also expressed the view that the recommended use of specific gravity as an indication of good-quality metal is likely to lead to wrong conclusions.

It is admitted that in general a high specific gravity is associated with good-quality metal and high tensile strength. The average results given in the Sub-Committee's Report give almost straight-line relationships, but individual results are very scattered for both gunmetals. Taking G.M.2, for example, densities of 8.33 and 8.92 are shown for tensile strengths of 15.8 and 15.6 tons (C.2, large bar, 1,200 deg. C., and C.1, small bar, 1,100 deg. C.), and densities of 8.58 and 8.66 are associated with tensile strengths of 18.8 and 14.0 tons (C.2, small bar, 1,200 deg. C., and A., small bar, 1,150 deg. C.). Tests made personally showed that little variation in density occurred in a series of four bars from 15 to 18 tons tensile.

With these thoughts in mind, it was deemed desirable to sound a warning note, as, if the method is definitely recommended, density may be accepted as having a closer relation to tensile strength than is actually the case, and the simplicity and cheapness of the test might easily lead to the adoption of a method of doubtful accuracy.—Yours, etc.,

G. L. HARBACH.

Worthington-Simpson, Limited,
Lowfield Works, Newark-on-Trent, Notts.
November 3, 1936.

London Iron and Steel Exchange

It is already assured that there will be a record attendance at the annual dinner of the London Iron and Steel Exchange at the Dorchester Hotel on November 10. Mr. C. Bruce Gardner, Chairman of the Exchange, will preside and the guest of the evening will be the Rt. Hon. Walter Runciman, M.P., President of the Board of Trade. Among those who have signified their intention of being present are the Earl of Dudley, Lord Greenwood, Lord May, Lord Hyndley, Sir Andrew Duncan, Sir Walter Benton Jones, Col. Sir Chas. Wright, Bt., Sir Edward Peacock, Sir Gerald E. Chadwyck-Healey, Bt., Sir Horace Wilson, Sir William Firth, Sir William Larke, Mr. B. G. Catterns (Deputy Governor of the Bank of England), Mr. Norman L. Hird (general manager of the Union Bank of Scotland), Mr. A. C. MacDiarmid, Mr. S. R. Beale, Mr. L. D. Whitehead, Mr. Leonard Browett, Mr. A. L. McColl, Mr. Nigel L. Campbell, Mr. Spencer Summers, Mr. I. F. L. Elliot, and others.

The Rise in Copper

By ONLOOKER.

Events in copper during the past few weeks have developed very swiftly, and a situation has now arisen which is fraught with interest and pregnant with possibilities. That consumption of copper is on an excellent scale cannot be gainsaid, but the quotation would never have climbed so fast or so far had not speculators bought in a most spectacular manner, following the rise much further than most people anticipated when the upward movement began. Copper had begun to enjoy something of a boom in popularity before France abandoned gold, but since that event enthusiasm has quickened materially, and at the time of writing the speculator has fairly got the bit between his teeth and is rushing his fences with a vengeance. Day after day there have been advances of from 5s. to 10s. per ton, and still the buying has gone on with a turnover on the standard market of nearly 20,000 tons a week. Consumption, though good, is not on such a scale as that. The limelight is on all the commodities at the present time, but particularly on copper, which is acclaimed as the most promising.

Production Cuts Cut

The rather extraordinary thing about recent developments has been the manner in which those producers who are parties to the curtailment arrangement have made successive percentage increases in the rate of production. These have taken the form of a whittling-away of the 30 per cent. cut in production which came into force about half-way through last year. As from November 1 output on the basis of the 1935 quotas is cut by only 5 per cent., and even this may be eliminated in the very near future, for stocks have been depleted at the rate of about 25,000 tons every month lately, so that consumption is obviously outstripping production.

All this additional copper has not scared the speculator, who has continued to buy hand over fist. The increased supply so far provided by the producers' action amounts to about 200,000 tons per annum, and this tonnage is going to take a good deal of absorbing—good as demand is. The question is, of course: will this demand not only be maintained but even increased during 1937? This aspect has become a subject of hot debate among all connected with copper at the present time. Trade on both sides of the Atlantic is still expanding, and in America particularly there is every promise that activity will grow still more as the utility companies enter the market for supplies.

Many people do not hesitate to declare that the rise in price must put a check on demand, arguing that substitutes will assume a much greater importance than they have done hitherto. This may or may not prove to be correct, but in any case it must not be forgotten that other commodities which have proved to be rivals to copper have also advanced in value during this year, so that relatively copper is not much worse off. A notable exception is aluminium, which remains at £100 per ton. Probably this danger to copper will not be much in evidence so long as the present boom lasts, but the trouble will come when demand begins to ease off and the weak spots show up. The price of £45 for electro, hitherto considered to be the high limit, has been passed, and now stands at about £48 10s., and it is said that the low-cost producers are disturbed at the runaway trend of the market. What more they can do to end this state of affairs it is difficult to see, for if they turn on the tap too freely the result will be a flood of unwanted copper, which will mean a slump.

The British Cast Iron Research Association

FIFTEENTH ANNUAL REPORT

[Abstract.]

The Council of the British Cast Iron Research Association reports progress in research and development and in other activities for the year ending June 30, 1936. The statement of accounts shows that the income has been the highest yet reached in the history of the Association, and the minimum of £7,000 from industrial grant-earning subscriptions, required in order to earn the grant of £5,000 from H.M. Government, was obtained without the necessity for a special appeal to members. The Council express the hope that the increased prosperity of the industry, the country's tariff policy and the need for greater scientific knowledge in the industry to keep pace with foreign developments, will induce all eligible firms to support the Association as members.

Council and Officers

Annual Meeting.—The fourteenth annual general meeting was held in London on October 30, 1935. Major F. A. Freeth, O.B.E., D.Sc., F.R.S., was unanimously re-elected President, and Mr. John Cameron, J.P., Mr. A. McKinstry, M.Sc., M.I.E.E., M.I.Mech.E., and Mr. H. James Yates were unanimously re-elected Vice-Presidents. Over 130 members and guests attended the annual luncheon which followed the meeting.

Officers.—Mr. H. B. Weeks, F.I.C., was re-elected chairman of Council and Mr. J. T. Goodwin, M.B.E., vice-chairman. Five meetings of the Council have been held during the year, with an average attendance of fourteen. The Council is indebted to the Iron and Steel Institute for the loan of a room for meetings held in London.

Research and Development

Grey Iron and Nickel and Alloy Cast Iron Sub-Committee.—An essentially fundamental investigation being conducted by the Association is that on the formation of graphite in cast iron and its modification. The process evolved for the refinement of graphite by the incorporation in the melt of a small amount of titanium and subsequent treatment of the melt by means of an oxidising gas, referred to in the last Report, has led up to a theoretical explanation on the following lines.

It is suggested that graphite originates not, as proposed in an earlier theory, from undissolved graphite nuclei, but from particles of a crystalline but non-metallic character. The titanium process effects a remarkable refinement of graphite from the coarse to the extremely finely divided state, probably by the formation, during the gas treatment, of a low-melting titanium slag which envelopes the non-metallic particles already present. Because this envelope is fluid, the particles are prevented from exerting an inoculating action, thus permitting the metal to solidify in the supercooled state, the graphite assuming a very finely divided form. The original coarse structure can be reproduced by treatment of the melt with hydrogen, which has a reducing action on the slag envelopes.

Various other pieces of evidence support the view that coarse graphite originates from non-metallic and particularly from silicate inclusions. For example, if an iron, extremely low in silicon, be graphitised wholly by nickel, the graphite takes the same finely-divided supercooled form as that found in the titanium process. The same remark applies to aluminium, if care is taken to exclude its oxide. In the presence of silicon both elements yield a coarse graphite structure. Furthermore, when an ordinary grey cast iron contains copper below the limit of solubility, the graphite, although refined compared with a copper-free iron, retains its essentially flake character. In the presence of copper, however, in excess of the solubility limit, the graphite assumes the supercooled or finely divided form. The suggestion again is that the excess copper thrown out of solution coats the non-metallic inclusions with an envelope which is fluid at the temperature of solidification of the melt. There is reason to believe that, although white iron does not contain free graphite, an analogous change occurs in white iron when subjected to treatment on similar lines.

Although the theory of the undissolved graphite particle as the origin of graphite flakes has been abandoned, the nucleus theory still holds, the non-metallic inclusion now being regarded as the nucleus. The work reported above on the production of fine graphite structures is expected to throw a good deal of light on the production of high quality irons of the inoculated type.

This work throws into prominence the non-metallic inclusion as the focus of metallurgical interest, and the same position holds with regard to steels and non-ferrous metals. The work has been reported to the Institute of British Foundrymen, and to the Iron and Steel Institute, by the senior metallurgist and Mr. Morgan, and the process is covered by British Patent 425,227. In view of the importance of the non-metallic inclusion, its nature and distribution, apparatus has been set up for the purpose of separating non-metallic inclusions from pig-iron and cast iron with a view to their subsequent analysis, and several separations and analyses have now been made.

By arrangement with the Iron and Steel Industrial Research Council of the British Iron and Steel Federation, the process of refinement is being applied in the manufacture of ingot moulds, to see whether the refinement of the graphite will diminish the disintegration of the mould surface due to the attack of molten steel. A series of ingot moulds has been made, both treated and untreated, and these are now in service. There are special difficulties in realising the formation of supercooled graphite from the cupola, but it should not be necessary to go the whole way from coarse to extremely fine in order to obtain a useful improvement. The Metallurgy Research Board of the D.S.I.R., of which the Director is a member, has approved of a group of members of the Board, representing both ferrous and non-ferrous practice, giving special attention to and interchanging views and ideas on non-metallic inclusions.

The investigation on shrinkage and contraction has been delayed by a change in staff, but is now being actively continued.

The Association is assisting in the revision of British Standard Specification No. 321 for grey cast iron and in the formulation of specifications for high duty irons for gear wheels and general castings, both plain and alloyed. The data derived from a series of tests undertaken in conjunction with Vickers-Armstrongs, Limited, Barrow-in-Furness, has been of value in this connection, and it is hoped shortly to present a complete report on these tests.

The necessary preliminary work on the influence of copper on cast iron has been completed and reported to members and a report on the influence of molybdenum is in draft. The work on copper is now being completed. Experience on the influence of aluminium in cast iron had shown the desirability of undertaking a more extended investigation than has hitherto been possible, and this was begun during the year. Aluminium irons have properties which are likely to be of considerable value in the industry, but their use has been rendered virtually impossible by the readiness with which aluminium oxidises during melting. This causes inclusion of aluminium oxide in the metal, with accompanying porosity, and yielding inferior mechanical properties. The investigation has, therefore, first been directed towards overcoming this difficulty, with very promising results.

Melting Practice and Sands and Refractories Sub-Committee.—The work reported as started last year by the Melting Practice Sub-Committee on the melting quality of a series of metallurgical cokes, undertaken in conjunction with the London Midland & Scottish Railway Company, at Derby, has been completed, and the data is now being examined and a report prepared. Some of the tests have been kindly carried out by the Northern Coke Research Committee.

The rotary furnace panel of the Melting Practice Sub-Committee has held three meetings, and has discussed the problems involved in the metallurgical control of these furnaces, including the question of linings.

The last report recorded that 95 balanced-blast cupolas were installed or under construction, with an aggregate hourly output of 670 tons. The total number installed or under construction at the present time is 141, with an aggregate hourly capacity of 1,078 tons. The situation with respect to metallurgical coke lays further stress on the importance of economy which this furnace offers.

Considerable progress has been made in an investigation on the use of certain naturally-occurring clays as bonds for moulding sands, both natural and synthetic, and a number of reports have been considered by the Sands and Refractories Sub-Committee. Towards the end of the year, Dr. J. G. A. Skerl, who had been in charge of research and development work for the Association on moulding sands and refractories, first at Sheffield and later at headquarters, left to take up an industrial appointment. Dr. Skerl remains a member of the Sub-Committee. In June, 1936, Mr. W. B. Parkes was appointed to take his place. Mr. Parkes has had considerable experience in moulding and core sands and refractories for both iron and steel founding at the Austin Motor Company, Limited, and has already been of considerable assistance to members requiring advice on sand problems.

The problem of refractory linings for cupolas, rotary furnaces, etc., has had attention, mainly by way of examination of samples from members, the service life of which is known.

Other Sub-Committees.—The Tests and Specifications Sub-Committee has considered proposals involved in the revision of B.S.I. Specification 321, and has also dealt with minor investigations for the improvement in accuracy and speed of analytical methods.

The Pig-Iron Sub-Committee has completed the revision of recommended tolerances for foundry pig-iron, and these have been circulated to members. The Sub-Committee also proposes to formulate a basis for the grading of foundry pig-iron according to type.

The White and Chilled Iron Sub-Committee has arrived at a tentative agreement respecting chill test pieces for use in controlling production and on the effects on chill of elements of composition, pouring temperatures, etc.

The Malleable Cast Iron Sub-Committee has considered work done on the impact strength of malleable cast iron and on the strength of malleable cast iron at elevated temperatures, in which considerable assistance has been rendered by Mr. W. B. Parker. Developments in the manu-

facture of malleable cast iron have been actively discussed, and the standard malleable test bar has been considered.

Co-operative Investigations

Combined Stress.—Of the three irons reported last year as supplied to the National Physical Laboratory Engineering Department for combined stress tests, the data on one, a brittle five per cent. silicon iron, have been presented to the Institution of Mechanical Engineers by Dr. Gough and Mr. Pollard, along with data on two steels. The results are of considerable interest.

Cast Crankshafts.—The work initiated last year on combined stress tests at the N.P.L. on certain commercially-available cast crankshaft materials has been continued, and two reports have been received. Tests on the remaining materials are approaching completion.

High-Temperature Tests.—The results of tests on five cast irons supplied by the Association to the N.P.L. with respect to their behaviour under creep and growth at elevated temperatures were presented to the Iron and Steel Institute in May in a Paper by Mr. Tapsell, Dr. Becker and Mr. Conway. The irons were plain engineering and alloyed engineering irons, Silal, Niresist and Nicrosilal.

Iron and Steel Industrial Research Council.—Work done in co-operation with the Iron and Steel Industrial Research Council on ingot moulds and on metallurgical coke (with the Northern Coke Research Committee) is referred to above.

Development Department

Members' Inquiries.—The Development Department assists members in dealing with practical or technical difficulties and advises on developments members wish to make. During the year, 1,140 inquiries and problems were reported upon (about four per working day) and arising therefrom a large number of visits have been paid to members by the staff.

Laboratories

Headquarters.—During the year the chemical laboratory carried out between four and five thousand duplicate estimations, and in the metallographical laboratory over 1,100 micro-examinations were made. In the mechanical testing laboratory about 2,000 tests of various kinds were conducted. Over 200 melts were made in the melting shop and cupola. In the sands laboratory about 1,000 tests for strength, permeability and mechanical analysis were made on sands and refractories supplied by members, in addition to over 1,300 tests in connection with the sands research programme. During the year the chemical laboratory has been extended and equipped for the study of non-metallic inclusions in pig-iron and cast iron. The microscopic laboratory has been equipped with a Vickers photomicrographic apparatus. A very small cupola has been made and an oil-fired crucible furnace installed.

Scottish Laboratory.—Mr. H. Cowan, as superintendent of the Falkirk laboratory, is fully engaged on visits to and work arising out of problems from Scottish members. The contact between Scottish members and the Falkirk laboratory has been strengthened by arrangements made during the year to distribute circulars and reports to all Scottish members direct from Falkirk.

Publications Committee

Library and Information Bureau.—The library continues to be largely used by members. The number of loans during the year was 2,070 and the number of accessions 450.

Exhibitions.—The official visit to the British Industries Fair took place in February. The Association participated in joint research exhibits at the Shipping, Engineering and Machinery Exhibition in September, 1935, and at the Chemical Engineering Exhibition in June, 1936. Both of these took place in London, the exhibits being arranged through the Department of Scientific and Industrial Research.

Foreign Visits.—In February, 1936, the Director attended a conference at Aachen Technical High School, organised by Prof. E. Piwowarsky, and spoke on foundry research in England. At the end of the year a visit was planned and organised to German foundries in conjunction with the International Congress and Exhibition held at Düsseldorf in September, 1936. This visit was the third of its kind, previous ones having been arranged by the Association in 1925 and 1929.

Papers and Lectures.—In addition to several talks by various members of the staff to various engineering and metallurgical institutions, a Paper was given by Dr. Norbury and Mr. Morgan to the annual conference of the Institute of British Foundrymen at Glasgow in June, on the fracture of pig-iron and cast iron. This included the first public statement on the titanium refining process referred to above, and which was fully dealt with by the same authors in a comprehensive Paper to the Iron and Steel Institute in October, 1936. The Director presented a Paper to the Chemical Engineering Congress on modern cast irons in chemical plant equipment. The Director also gave the Exchange Paper of the Institute of British Foundrymen to the Düsseldorf Congress.

Study Course.—The second study course was held from November 6 to 8, 1935, inclusive. Over one hundred members registered for the course, and were welcomed by the chairman of Council. During the mornings sixteen talks were given by twelve members of the staff, and a talk on coke was given by Prof. H. L. Riley. A general discussion also took place on foundry problems. During the afternoons demonstrations were given in six laboratories. Four visits were also arranged to works to see special items of equipment in operation, and the warm thanks of the Council are due in this connection to the British Thomson-Houston Company, Limited, Rugby, to the Audley Engineering Company, Limited, Newport, to Birmingham Electric Furnaces, Limited, and to the British Piston Ring Company, Limited, Coventry.

Members' Meetings.—Following a kind offer by the President, arrangements were made to hold a members' meeting on February 12, 1936, to hear Major Freeth speak on "The Phase Rule Applied to Metals and Alloys." Indisposition prevented him from doing so, and thanks are due to Dr. D. Hanson, Professor of Metallurgy at the University of Birmingham, for speaking on the subject at short notice to members and staff. The President duly gave his postponed lecture on July 23, 1936.

Education Committee

Staff Education.—Junior staff employees have in all cases undertaken part-time educational courses, designed to lead to a professional certificate or to an external degree. A number of representatives of members have also been received at the laboratories for long or short periods for training in some special branch of laboratory technique.

British Foundry School.—The British Foundry School, in the establishment of which the Association has actively assisted, completed its first session in August, and thirteen students duly took the diploma. The annual report and statement of accounts, giving full details of the year's work with the syllabus and lectures, will be forwarded to anyone interested.

The demand for trained men at the present time is such that it exceeds the supply, and the school will be found an admirable means of training promising young men of suitable education and practical experience for higher responsibilities, within the very reasonable time of one year.

Finance and Membership

Accounts.—The accounts circulated to members with this report show a total income for the year of £14,118 and a total expenditure of £13,678. The income is the largest in the history of the Association. At the same time it has not been possible to earn more grant than the limit of £5,000 given for an industrial and grant-earning income of £7,000. The whole of the remainder of the income was non grant-earning. For each £250 earned in excess of £7,000, by industrial subscriptions or donations, a similar sum can be obtained in grant. Last year, however, it was possible to raise the £7,000 minimum, only by securing £300 by means of a special appeal to a group of members, which has not this year been necessary. A donation of twenty guineas from British Pigirons, Limited, is gratefully acknowledged.

Gifts.—Gifts of pig-iron have been kindly made by Vickers-Armstrongs (Ironfounders), Limited, M. & W. Grazebrook, Limited, Indian Iron & Steel Company, Limited; W. & T. Avery, Limited, have kindly provided a small single-blow impact testing machine.

Membership.—At the close of the year the total number of ordinary and trade members was 308, and associate members 56.

Staff.—During the year Dr. J. G. A. Skerl and Mr. H. Elliss resigned to take up industrial appointments. The former was succeeded by Mr. W. B. Parkes and the latter by Mr. A. A. Timmins. Captain J. W. Bampfylde, A.R.S.M., and Mr. E. Hinchliffe, B.Sc. (Eng.), A.R.S.M., were also appointed to the research staff.

Future Developments

The Council of the Institute of Vitreous Enamellers has considered the desirability of making provision for the conduct of research on vitreous enamelling, a type of finish now widely applied to cast iron. Representatives of the Institute have discussed with the Director the possibility of linking up with the Association for the conduct of this work, and have been given the fullest possible assurances of the Association's interest and of the practicability of a scheme of the nature outlined. This matter was referred to by Dr. J. W. Mellor, F.R.S., President of the Institute, and Mr. W. H. Whittle, Chairman of Council, in reports given in THE FOUNDRY TRADE JOURNAL for October 8, 1936. Other research developments are under discussion.

Accommodation

The Association acquired its first laboratory by renting temporary premises in 1924. In 1926 the offices and laboratory were combined in premises in St. Paul's Square, and since that date various changes and extensions have been made. The total area now available at headquarters is 9,000 sq. ft. The last few years have shown the difficulties of carrying out the steadily extending work of the Association in these premises, and the time is rapidly approaching when the question of more suitable accommodation must be considered by the Council. The Council during the year agreed to set up a building fund and to make such provision for it from the Association's slender reserves as is practicable from time to time. The Council wish to draw attention to the necessity for contemplating this question in the not distant future, and to commend the object in view to members generally.

The Report is signed by Mr. H. B. Weeks (Chairman of Council) and Mr. J. G. Pearce (Director and Secretary).

Stainless Steel Aeroplane

The first stainless-steel aeroplane to be built for commercial purposes has just been put into service at Bristol, Pa. The plane is a four-passenger cabin machine, and was constructed by the "Shotweld" process for fabricating stainless steel.

Welding *versus* Casting*

IMPROVING FOUNDRY TECHNIQUE TO MEET THE COMPETITION

By MATTHEW RUSSELL

Fabrication

As a method of construction, fabrication has applications in many respects because the fabricated design is so simple, and credit must be given to the designers on this account. The designers of castings in most cases have no knowledge of patternmaking and moulding methods, and their construction often leads to prohibitive costs. For confirmation of this, one only requires to examine castings produced to drawing-office requirements.

This state of affairs has existed for so long that the engineers now look upon the pattern-shop costs as being too high on a competitive basis, and in their search for cheaper substitutes they are adopting weldings. In doing this the engineers are compelled to leave their designs in the welders' hands. If one compares the

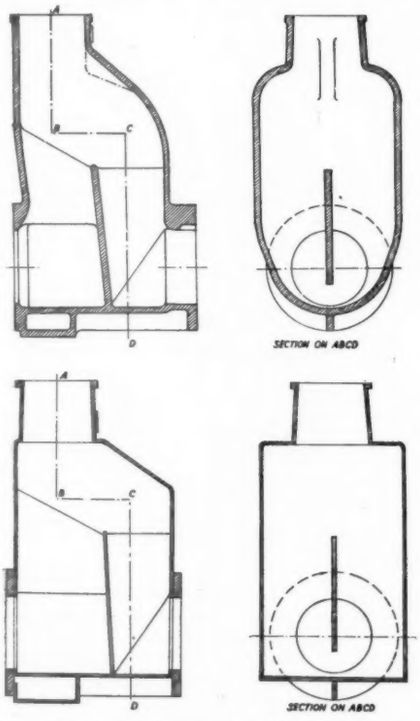


FIG. 1.—UPPER SKETCH "AS DESIGNED" FOR CAST IRON AND LOWER SKETCH "AS MADE" BY WELDING.

design of an article produced by this method with the original design called for as a casting, it is often found that there is a considerable saving in favour of the welded material, purely by simplified design alone.

This, surely, is not a fair comparison, as one may find that, merely by adopting the fabricated design, the position could be reversed in favour of the casting, providing that the moulder and coremaker keep their product to the desired thickness, and do not add anything up to 25 per cent. to the weights, owing to the fact that both their employer and themselves are being paid by weight. This increasing of weights may appeal to the founder as being good business, but it is a very short-sighted policy, and, in fact is craft suicide in face of competition with weldings.

A typical example is shown in Fig. 1 of a welded article submitted, as called for, as a casting; this shows the difference in design necessary when made as a welded job. The cost when fabricated is equal to that of casting, which would include half pattern and half corebox, with alteration pieces, *i.e.*, if the same design were adopted. This illustrates how increased costs are brought about in patternmaking by having to follow original design with large rounded corners, whereas if collaboration with the patternshop were adopted, as was done in this instance, castings would be cheaper after making one off, as subsequent castings would not carry the cost of the pattern.

This illustration and comparison was based on estimates taken from several firms specialising in weldings, and alteration in design was necessary on all of them. Had a rounded-corner design been insisted upon, their price would not have been comparable with the casting price, including pattern, by 30 per cent. Other illustrations will be given later of altered designs from the patternmakers' viewpoint, showing considerable savings which were only brought about by the competition of weldings; all of these were produced as castings and were definitely competitive. It might also be noted that castings were desirable due to their having greater rigidity and representing a better job.

Designs

It is difficult to understand how any designer can carry out his work competitively without having a general knowledge of patternmaking and moulding methods. This desirable condition of affairs, however, is more often found wanting than existing. One can imagine the draughtsmen declaring that it is impossible to expect this, but let them be assured that it is now being done, and is showing exceptional advantages as regards reduction of costs wherever adopted. Comparison of results obtained under the best designed conditions, when the patternshop and foundry methods were subjected to proper planning before proceeding, have shown that, in the majority of cases, the castings were cheaper than weldings, and more satisfactory, being less liable to distortion.

It is obvious in many cases that the success of this method has been more or less brought about by the costly procedure of obtaining castings, that is to say, principally due to the cost of patterns where one-off jobs are concerned. No doubt many, whilst agreeing in this respect, do not consider the possibility of any remedy, but a personal recommendation is to specialise in design from the patternshop and foundry viewpoint, and there will at once be exceptional savings.

Several typical examples are shown in Fig. 2, *et seq.*, of actual work designed without the designer having shown any knowledge of or given any thought to patternmaking and foundry methods. It will also be noted that the alternative designs show definite savings in manufacture without any objectionable alterations.

Patternmaking

The same conditions exist with the patternmaker as with the designer on account of his lack of knowledge of foundry methods. He is often inclined to make unnecessarily expensive patterns and coreboxes, whereas, in many instances, shell patterns or skeleton patterns without coreboxes could be adopted. Typical examples are given in the sketches already submitted, which show simplified designs and alternative methods of making patterns with comparative costs.

Bearing Brackets

Fig. 2 shows bearing brackets as originally designed; the general practice would be to make two half patterns with prints shown etched and with separate cores for windows A, leaving end B to be worked loose in the mould, and with half main corebox. The cost of this pattern would be £9 10s., including time and timber.

An alternative method.—To simplify the design make a half pattern and half corebox, and cut out a window on the pattern to the outside shape of the main core. The cost of this pattern including time and timber would be £6, and no more time would be added to the moulding cost. The only objection to the half pattern would be that most jobbing foundries maintain they have not suitable plant. A method of overcoming this was introduced by the author, and is working most satisfactorily (*vide* illustration and comments under "Moulding").

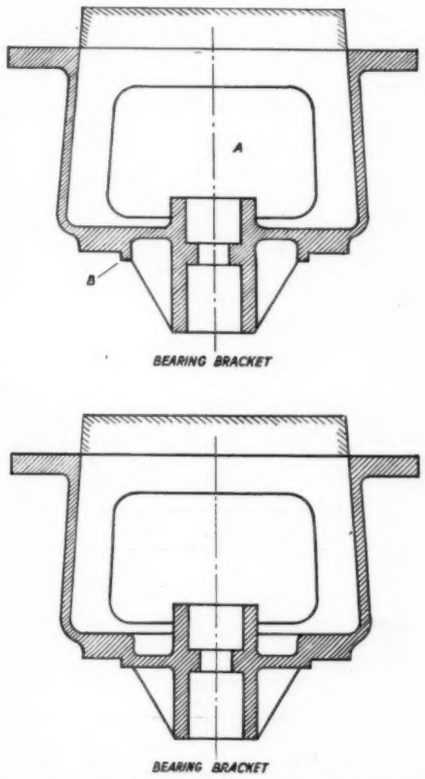


FIG. 2.—UPPER SKETCH "AS DESIGNED," AND LOWER SKETCH "AS MADE."

Bedplate (Fig. 3)

The general practice for making this bedplate would be to have a pattern with corebox owing to the high sides A and B, whereas if the design were made with open sides, as shown at C and D, and webbed, a shell pattern leaving its own core would be made, thereby enabling the moulder to make gratings and to ram up the side cheek cores in place. A pattern of this description could be produced at half the cost of the general practice type, and is, moreover, simpler to mould.

Axial Casing (Fig. 4)

For this axial casing the usual method would be to have two half patterns and a half corebox, whereas the alternative design was made with a half pattern and half corebox. By adopting the straight-line design instead of the stream-

* This Paper, read before the Scottish Branch of the Institute of British Foundrymen (Mr. F. Hudson presiding), was awarded the Surtees Gold Medal.

line, the pattern was produced at about one-third of the cost, and no increase was made on the casting cost.

Pump Casing with Cast-on Stools (Fig. 5)

This pattern was parted on line AB, and previously was a standard pattern without stools. The draughtsman designed it as is shown, that is all cast as one and embodying the top and bottom bearing. The alternative design shows

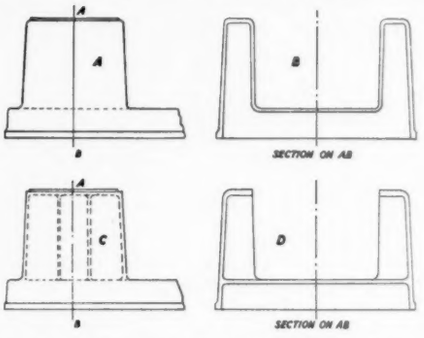


FIG. 3.—A BEDPLATE CASTING. UPPER SKETCH "AS DESIGNED," AND LOWER SKETCH "AS MADE."

the top and bottom bearing with the stools cast separately, the same pattern being used for both stools with increased bottom base flange, thus making a very much simpler casting. As the component is now in three pieces, should there be a defective part, the cost of replacement would be considerably reduced. Patternmaking costs in this instance were reduced by 50 per cent., and the casting rate for stools was also reduced 10s. per cwt. compared with the cost of the centre casting.

The author has studied the simplicity of designs for the last two years, and the four cases

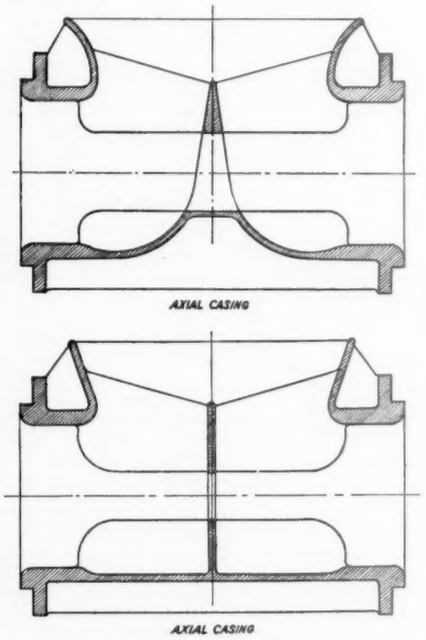


FIG. 4.—UPPER SKETCH "AS DESIGNED," AND LOWER SKETCH "AS MADE."

submitted are representative of the hundreds that have been dealt with in this manner. If this system were adopted in general, there would be no fear of competition from weldings, as the author's firm are continually taking comparison costs, and can easily hold their own competitively. It must, of course, be realised that their patternshop lay-out is excellent, being considered in the same manner as in general machine-shop practice.

The reason for the adoption of fabrication in a great many cases is not the cost of the casting, but of the pattern. This is not surprising, as many patternshops are being run under the same conditions that have existed for the last 50 to 100 years. Very few firms give any thought to the patternshop lay-out with a view to improving these antiquated methods, although they spend thousands of pounds keeping the machine shops modern and condemning pattern-shop costs. Why this state of affairs should exist is beyond comprehension, as there are specialists in the manufacture of woodworking machinery, although most of their products are being used in the furniture and building trades.

Patternshop Lay-Out

The first operation involved is to secure and cut the timber. The wood rack is placed vertically at the extreme end of the shop, and not horizontally, as is the general practice. The reason for this is that the patternmaker can select the boards required without incurring the necessity of removing others. Alongside the wood rack, a cross-cut saw stands immediately behind a long table on which the timber to be cut is placed, and the saw is drawn forward by hand through the timber with very little effort on the part of the operator. All the machines

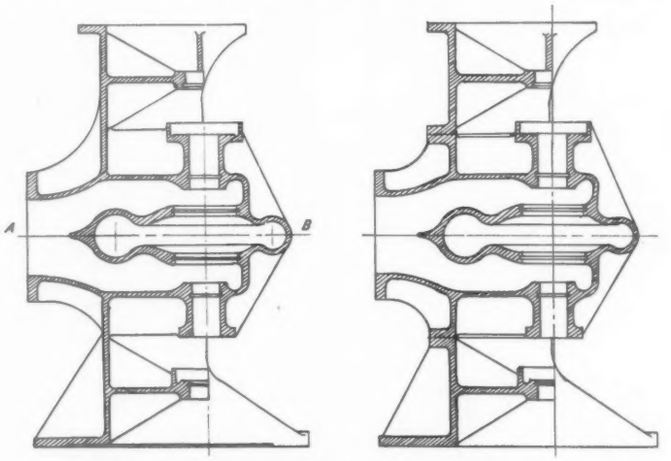


FIG. 5.—LEFT-HAND SKETCH "AS DESIGNED," AND RIGHT-HAND "AS MADE."

are push-button electrically controlled, and self-contained. After the timber is cut to length, the next operation in the natural sequence of working is to reduce it to the desired width on the saw bench. A machine of the latest type is placed adjacent to the cross-cut saw and is suitable for dimension sawing, including ripping, mitreing, and angular cuts and bevels.

Still following the actual progress of the work, there is next the planing and thicknessing of the timber. To do this a surfacing machine is installed next to the ripping saw for straightening the boards before they are put through the thicknessing machine, which is adjacent to the surfacer.

The next machines are two band saws, one 30 in. and one 24 in. The reason for there being two is that as blades ordered for the large machine become shortened they may be used for the smaller machine, thereby making a saving. These machines are placed at convenient parts of the shop to save the patternmaker walking. There are also a large double disc sander and a double bobbin sander, which are suitable for finishing work straight from the band saw either hollow or round. In addition there are three 12-in. portable sanders, a portable 12-in. cross-cut saw, and a portable band saw; all of these can be placed alongside a job employing several patternmakers, thereby eliminating waste of the patternmakers' time in walking about the shop. There are five 6-in. electric planing machines which are placed between each two operators, and these eliminate hand planing, which would otherwise take up a great amount of time. Rotax drills placed on stands are used as small verticals for boring screw-nail holes. Patterns produced under these conditions are definitely modern, and show a 60 per cent. saving in costs as compared with general methods.

Moulding

The moulder, who is the victim of circumstances so far as design and construction of patterns are concerned, is generally blamed for increased costs in producing the castings, whereas if the originally suggested methods of procedure were adopted, namely, collaboration with designer and patternmaker, this unsatisfactory state of affairs would be eliminated. No doubt moulders will say "not practical," or "we have no time for this," but they are assured that, like the savings shown in the production of patterns, this is at present being done in a number of the foundries with which the author is connected, to the detriment of the adoption of weldings in a great many cases.

Recently a system of recording any job which gives trouble in making has been adopted, and this has been found a great advantage in eliminating defective castings. Welding specialists claim that their method of production involves no waiting for replacements, such as is associated with castings, and one has to admit that in most cases the chances of success or error in foundry methods are considerable.

A typical example of the method of recording is shown of a large rotor (Fig. 6), from which, prior to the adoption of this method, six bad castings were made. Since adopting the newer methods there have been no bad ones. The author is also a strong supporter of having gates and risers fixed on patterns, as, by so doing, consistency of method is assured.

Regarding the adoption of half patterns, a sketch of this lay-out is shown in Fig. 7, and this has been used in many jobbing shops where the boxes were very dilapidated, but it makes no difference if the plate is straight and of even thickness. This is the kind of gear that requires general adoption. The writer also does a great amount of work having skeleton patterns without coreboxes, the cores being made from clayed thicknesses. This method is found to have great advantages where one-off is wanted, and is definitely the kind of procedure necessary to compete with weldings.

Clay Thicknesses

It might be an advantage to explain briefly the method of clay thicknesses. The pattern is

moulded in the usual manner, and a flat board with strips, say, 8 in. apart and about 12 in. long, equal to the thickness of metal required, is utilised for rolling out slabs of clay; these slabs are then put round the moulds. It might be considered that it would be necessary partly to bake the clay to ensure it being strong enough to resist the ramming of the cores, but when one becomes accustomed to the method, the clay can be made in such a manner as to eliminate this. Any part that may be carried in design, as regards internal rings, is made of wood and placed in the moulds. Core irons are then placed in the moulds, which are used as substitutes for coreboxes. This procedure is being adopted in quite a general way, and definitely shows considerable savings in pattern-making costs where one-off is concerned. The manner in which most jobbing foundries are laid out makes them anything but desirable places in which to work, yet no trade has greater possibilities for the man with initiative.

Regarding the mechanisation of foundries, this certainly has been done, especially in the motor car and mass production industries for which the author has quite a number of patterns made

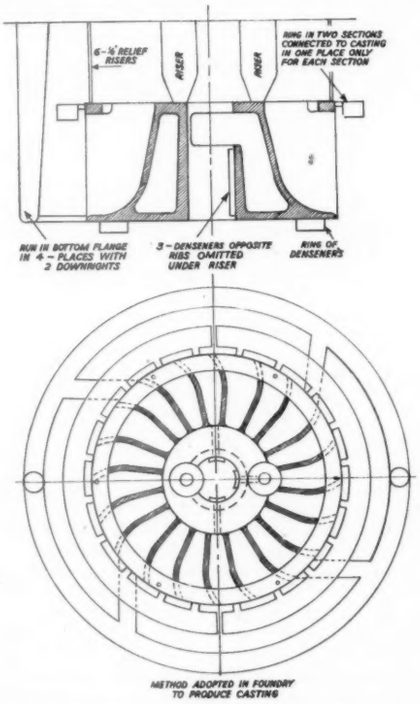

6-½" RELIEF RISERS
RISER
RISER
RING IN TWO SECTIONS CONNECTED TO CASTING IN ONE PLACE ONLY FOR EACH SECTION
RUN IN BOTTOM FLANGE IN 4 - PLACES WITH 2 DOWNRIGHTS
3 - DENSENERS OPPOSITE RIBS OMITTED UNDER RISER
RING OF DENSENERS
METHOD ADOPTED IN FOUNDRY TO PRODUCE CASTING

FIG. 6.—METHOD ADOPTED BY THE FOUNDRY TO PRODUCE ROTOR CASTINGS.

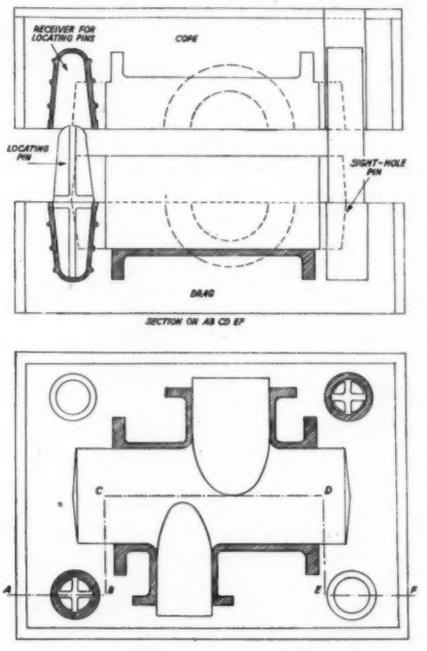


FIG. 7.—UPPER SKETCH: SECTION OF MOULD SHOWING ASSEMBLY OF COPE AND DRAG. THIS WAS MADE FROM SERVICE PLATE, WHICH ENABLES THE USE OF HALF PATTERNS OF A SYMMETRICAL NATURE.

in the block system, the castings being made by semi-skilled labour. It is not here where the fear of interference from the welding producers can take place, but in general jobbing foundries, many of which, like most patternshops, are working in much the same way as 50 and 100 years ago. By adopting methods on the lines suggested, and incorporating, on a semi-mechanised basis, such departments as sand handling and mould production the operations run in a sensible sequence, and the stoppage of the shop while the cast is taking place can be obviated.

Weight Saving

A large quantity of work has been secured by welding manufacturers principally on saving of weight. This question is not being competitively met in the proper manner by the designers of castings, as is illustrated by the following examples.

Two large Diesel engines were being manufactured by a well-known firm on the Clyde; the weight of each engine was 100 tons, and the welded parts were given the credit of having saved 40 tons per engine, although no credit was claimed for reduced costs beyond the saving of pattern charges. The top and bottom framing was approximately 30 ft. long, and if made as a casting would have been in two pieces, each 15 ft. long, and bolted together with internal flanges. On inquiring what thickness was allowed for the casting to give this enormous saving in weight in favour of the weldings, the author was informed 1¼ in., which seemed quite reasonable for a casting of this size. On the other hand, why could not this casting have been made in four pieces instead of two, thereby reducing the casting thickness to ¾ in.? This would have reduced the weight by 16 tons per set in ordinary irons. This saving could be further increased by the adoption of Meehanite iron, there being five processes of this exceptional iron, the price being controlled in accordance with the process required to suit conditions.

Basing the process on the cheapest class of Meehanite, which is superior in strength to ordinary iron, the thickness of the casting could be reduced 50 per cent. Disregarding the full advantage of this allowance, and instead of ¾ in. thick, calling it ½ in., the weight will be reduced by 22 tons per set. This weight saving can still further be increased by adopting a combination of Meehanite for the bottom framing and silicon aluminium for the top framing, thereby making the castings competitive with welding in respect to weight and price, provided the designer, patternmaker and moulder collaborate. The design could be made such that one section of the top and bottom framing, with modifications, could be used as the pattern for the other three sections. The author has quite a number of combinations with brass and silicon aluminium, also iron, all of which are recognised by the Admiralty on a weight saving basis, and under these conditions welding cannot claim such large percentages of savings.

With the education of the designer, patternmaker, and moulder, by taking advantage of the many training facilities that now exist, closer relationship such as takes place in the welding industry will be possible. Provided these facilities are extended to the draughtsmen and apprentices, one need have no fear of weldings beyond their acting as a stimulant to force foundrymen to use their brains for further development of the industry, to the mutual advantage of all concerned.

DISCUSSION

In opening the discussion the CHAIRMAN (Mr. F. Hudson) said that personally he had never been much perturbed over the problem of fabrication *versus* castings, as he considered the progressive foundryman would overcome most of the competition if some thought and action were given to the matter. Mr. Russell's Paper confirmed this statement and indicated in a very practical manner the methods to be adopted.

In any investigations that the speaker had conducted into welded structures, particularly so far as fusion welds made by the electric arc or the oxy-acetylene flame were concerned, he had always regarded the metal in the weld as being essentially a casting, and from this point of view the majority of welds were equivalent to an inferior casting. The striking feature of most welds was the low ductility of the metal coupled with unsound structure, cavities, oxide inclusions, etc. A good weld would only show 7 per cent. elongation, whilst an average weld might give 5 per cent. and a poor one nil. Furthermore, fatigue tests indicated that the metal in the weld had only about a quarter of the value of the steel itself. Welded structures could not possibly compete with castings, particularly grey iron, so far as wear and corrosion resistance were concerned. Keeping these facts in mind it should not be difficult for the founder to replace welding by the exercise of initiative along the lines suggested by Mr. Russell.

The manufacture of castings was an old-established industry, probably the oldest industry in the world, and Mr. Hudson asked himself whether foundrymen were taking things for granted, and philosophically tolerating the more aggressive tactics of that young offspring, "fabrication." In most iron castings the design was either antiquated or factors of safety were used that were unfair considering the great strides which had been made in improving cast iron during recent years. On the other hand, those responsible for the production of fabricated structures by welding were up to date in method and had no old-fashioned practices to live down. Often a job was changed to welding to lighten or cheapen it, but very often if, in its new design, it was presented to the founder and cast with one of the improved irons, it would probably cost less to make and be stronger and more robust. It was therefore a matter for the founder to change design as illustrated by Mr. Russell, and to show enough aggressiveness to have his improved design accepted by the engineer.

In the discussion which followed Messrs. D. Sharpe, J. Cameron, Junr., J. M. Primrose, J. Arnott, A. Lawrie, A. Marshall and R. D. Lawrie took part.

THE CHAIRMAN expressed the thanks of the meeting to Mr. Russell for his informative and interesting Paper, and the manner in which he had dealt with the discussion.

At the conclusion of the meeting the members and their ladies adjourned to the C'adora restaurant, where a social function was enjoyed.

Engine Castings for "No. 552."

An order for over 1,100 tons of castings for the sister ship to the "Queen Mary" has been placed with Harland & Wolff, Limited, Glasgow. The contract which includes gear cases, gear wheel centres, turbine casings, thrust blocks and pedestals, will be carried out at the firm's Clyde foundry and will provide employment for a large number of men over a period of months. Harland & Wolff, Limited, executed a similar contract for castings for the "Queen Mary."

Second Report of the Steel Castings Research Committee

BY A JOINT COMMITTEE OF THE IRON AND STEEL INSTITUTE AND THE BRITISH IRON AND STEEL FEDERATION

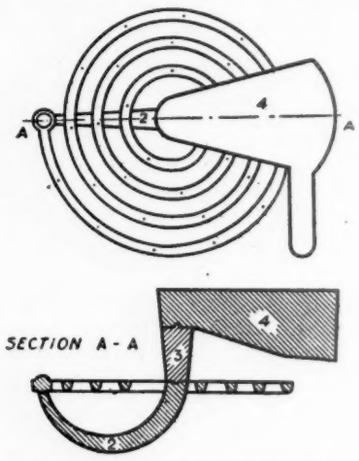
(*Continued from page* 319.)

SECTION III.—The Fluidity of Iron-Carbon and Other Iron Alloys

By PROFESSOR J. H. ANDREW, D.Sc., R. T. PERCIVAL, B.Met., and G. T. C. BOTTOMLEY, B.Met. (Department of Metallurgy, University of Sheffield).

Introduction

This investigation was carried out with the object of obtaining a definite measurement of the fluidity of steels under various conditions of casting, such as variation in the temperature



1. Spiral. 2. Horn gate. 3. Down gate. 4. Pouring basin and overflow.

FIG. 1.—SPIRAL CASTING FOR DETERMINING THE RUNNING QUALITY OF MOLTEN METALS IN A SAND MOULD (A. I. KRYNITSKY AND C. M. SAEGER, JUN., NATIONAL BUREAU OF STANDARDS JOURNAL OF RESEARCH, 1934, VOL. 13, P. 580).

and composition of the melt. Preliminary experiments were carried out with a view to designing a permanent mould, and, as will be shown, the results obtained were very erratic. Hence it was necessary to standardise the type

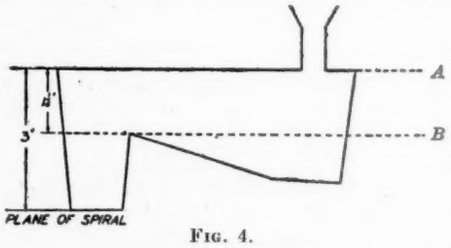


FIG. 4.

of mould, the method of moulding, and the materials used for moulding, in order that these might be repeated for every experiment, so that the length of spiral cast is a direct measure of the fluidity.

Having designed such a mould, curves have been obtained showing the relationships between:—(*a*) Temperature and fluidity for a definite composition and (*b*) composition and fluidity at a constant temperature.

The effects of mass and variation of casting temperature on the microstructures of the alloys have also been considered.

PART I.—The Factors on which Fluidity Depends

The distance which a metal flows round a spiral depends on:—(1) The casting temperature; (2) the composition of the metal; (3) the properties of the mould; (4) the temperature of the mould; (5) the rate of pouring; (6) the hydrostatic pressure of the liquid above the plane of the spiral.

Since the casting temperature and composition of the melt are known, and the initial temperatures of the mould will vary very little, the only factors to be considered are the properties of the material of the mould, the rate of pouring, and the hydrostatic pressure. Although no results have been obtained by using different mould surfaces or dressings, it is a well-known fact that in the case of cast iron the "life" is considerably increased by dressing the mould surface with soot or lampblack. A study of the effect of various dressings on the fluidity of steel should prove interesting in the present case. It was recognised that factors such as the condition

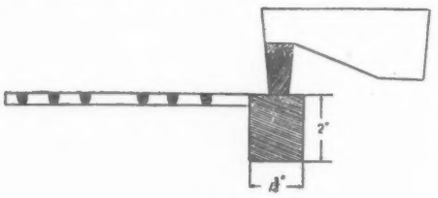


FIG. 2.

of the surface, permeability, and heat conductivity or chilling effect, should be kept constant, and any variation due to these effects must be eliminated in a permanent mould used for such tests.

Experiments with a Permanent Mould

The most suitable materials were alundum and sillimanite, with a split horngate. Spirals were therefore rammed up in alundum cement, two separate bonds being used:—(*a*) 60 per cent. of water and (*b*) 10 per cent. of silicon ester binder (13 per cent. Si).

These were fired to a temperature of 1,500 deg. C. The alundum spiral and split horngate were rammed up in a box with sand; the pouring basin and gate were then rammed in sand in another box, sand being used because the material in which the basin is rammed does not influence the length of spiral obtained, and the feeder head was moulded in a third box. The three parts of the mould were dried and fitted together so that the various portions of the mould were connected as shown in Fig. 1.

The first few test-pieces were cast from a small high-frequency induction furnace by placing the mould on a platform fitted with rollers and pushing it under the tilting furnace. In the first case the steel froze at the entrance to the spiral, hence it was decided to discard the horngate shown in the illustration, and the succeeding tests were top-poured at the outside of the spiral, with a blind reservoir beneath the plane of the spiral and directly under the down-gate. On every test there was a riser 1 in. in dia. at the centre of the spiral to prevent variations due to a back pressure set up by gases trapped between the metal and the end of the spiral. This spiral was marked every 2 in. in order that a measurement of the length of flow might readily be made. In the subsequent tables this is reported under the heading "Distance." Tests were carried out on steels of varying carbon content, with only traces of sulphur and phosphorus, the manganese and silicon contents being the same in each case, 0.3 and 0.10 per cent. respectively. Very erratic results were obtained, as shown by the following figures.

Cast No.	Carbon content, per cent.	Distance. In.
P 1	0.3	4½
P 2	1.2	3
P 3	1.2	8½
P 4	0.6	2½

Possible causes of the erratic nature of the results may be variations in temperature, and the nature of the mould. According to C. M. Saeger, jun., and A. I. Krynitsky,* the metal flows as a result of hydrostatic head pressure, and a number of factors oppose this, such as:—(*a*) The viscosity of the liquid itself; (*b*) friction

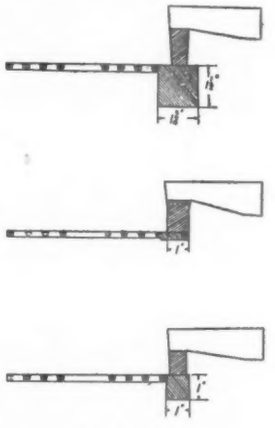


FIG. 3.

between metal and mould surfaces (affected by nature of the sand grains, nature of mould dressing and degree of packing sand); (*c*) surface tension of the liquid metal against the sand surface; (*d*) oxide or other films formed on the surfaces of the liquid metal (not so much on high-silicon alloy); and (*e*) gas pressure developed (from the sand or coating material). The degree of retardation depends on mould design, the moisture content of the mould and permeability of the sand rammed. Heat is also transferred to the mould, the rate depending on the sand/metal interface and moisture content of the sand (allowed since the moulds are baked).

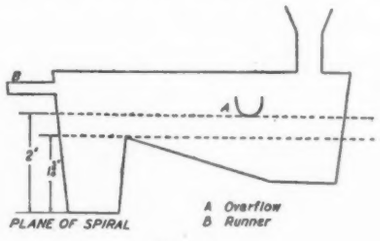


FIG. 5.

Measurement of Temperature

For the measurement of temperatures a tungsten-molybdenum thermocouple was used; by cutting off a few inches of wire and making a new junction for each reading, it was found that reliable and consistent readings could be obtained.

* Transactions of the American Foundrymen's Association, 1931, vol. 39, p. 513.

The closed sheath used was of porcelain, but it was found that different batches of these sheaths varied, some breaking as soon as they were put in the pot, so that no temperature reading could be obtained. Sheaths made of alundum cement, fired to 1,600 deg. C., were found to withstand the conditions much better, and readings were obtained more quickly, so that they were subsequently used instead of porcelain. Attempts were made to measure the temperature of the steel by inserting the couple in various parts of the mould, but the lag on the sheath was too great, and low results were obtained. This method was therefore discarded. It was found that, by dipping the couple in the pot before casting, a value for the temperature could be obtained.

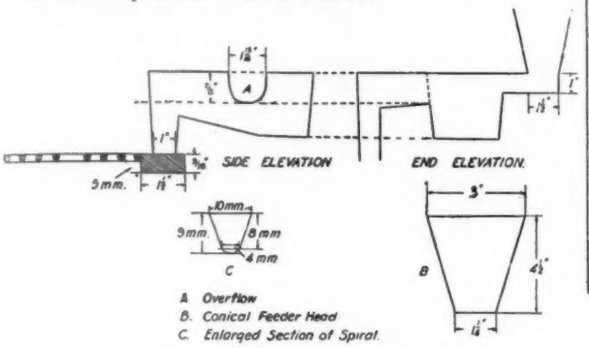


FIG. 6.

As previously stated, the mould was rolled under the furnace, and with this procedure it was difficult to keep the spiral horizontal, a necessary precaution for consistent results. Hence it was decided to use an oil-fired crucible furnace for the following reasons:—(*a*) The mould could be made stationary and horizontal; (*b*) larger masses of steel could be handled, and hence they would not chill so quickly; and (*c*) the temperature could be measured more conveniently by inserting the couple in the pot just before casting.

The following tests were carried out by this method of heating, the mould being designed as shown in Fig. 2.

Cast No.	Composition, per cent.					Distance. In.
	C.	Si.	Mn.	P.	S.	
P 5	0.52	0.07	0.64	0.01	0.028	1½
P 6	0.248	0.27	0.70	0.026	0.048	10

No temperatures were recorded, but *P* 6 was seen to be definitely hotter than *P* 5.

The following tests were cast from the same pot one after the other into moulds in which the capacity of the blind reservoir was varied, as shown in Fig. 3. The composition of the steel was:—C, 0.56; Si, 0.27; Mn, 0.72; and P, 0.02 per cent. The results were as follow:—

Cast No.	Capacity of reservoir.	Distance. In.
P 7	1¾ in. in dia. by 1½ in. deep ..	13
P 8	Small hollow	13
P 9	1 in. in dia. by 1 in. deep ..	7½

After considering these results, it was decided to decrease the capacity of the reservoir. All the above tests were carried out with three alundum spirals, one bonded with silicon ester and the other two with water. On examination, their surfaces were found to be friable, and in stripping the last three castings, all the moulds cracked. It was, therefore, decided to use a non-permanent sand mould. Core sand was used as a facing for the mould, since a definite amount of core oil (5 per cent.) can be regularly milled for the same time with a definite amount of silica sand to give a product, the physical properties of which vary very little; that is to say, to all intents and purposes the same mould surface is used for each test. Moreover, core sand is of such a nature that it possesses one degree of ramming and gives the castings a good surface without a dressing. The backing sand was Yorkshire sand diluted with floor sand. The whole mould was baked at a temperature of about 480 deg. Fah.

Experiments with Heated Moulds

It was considered that a heated mould would decrease the chilling effect and so give a longer spiral. Experiments were therefore conducted on these lines, but the results were disappointing. The same design of mould was used, the temperature of the heated mould being about 400 deg. C.

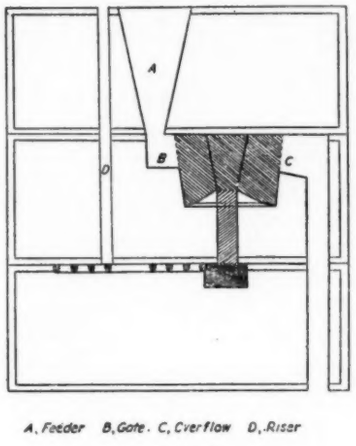


FIG. 7.

Cast No.	Distance. In.	
	Cold mould.	Hot mould.
P 10	—	7½
P 12	—	9
P 13	22	—

P 12 and *P* 13 were from the same cast, and the temperatures were approximately constant since they were poured one after the other, *P* 12 being first. The reason for the contradictory results may be due to the variable rate of pouring or to the fact that cast *P* 13 was more oxidised than *P* 12. This effect has been noticed by other investigators. In another cast also it was found that the second cast flowed further than the first.

Cast No.	Distance. In.
P 14	16
P 15	18

Fig. 4 shows diagrammatically how the head of liquid increases during pouring (by the amount between the dotted lines *A* and *B*), the actual increase being from 1¾ in. to 3 in., that is to say, the head is nearly doubled, and it is reasonable to expect that the rate of pouring will increase the length of spiral obtained.

Since the variables caused by the mould material have been eliminated, the only varying factors to be considered are the rate of pouring and head of liquid, which must, of course, be kept constant, in order to obtain consistent results. To cut down the increase, an overflow was arranged 1 in. from the top of the basin and ¼ in. from the top of the down-gate, as illustrated in Fig. 5. The head, therefore, only increases from 1¾ in. to 2 in., the increase being one-fifth of that previously obtained.

P 17-19 were cast one after the other after taking the temperature. Thus, allowing for the fall in temperature between the casts, there is a fairly good agreement between these figures.

Final Design of the Mould

The shape and dimensions of the mould finally adopted are depicted in Fig. 6, and Fig. 7 represents a section as rammed in the boxes. There is a riser at the centre of the spiral, and the feeder is arranged to form a side gate to the basin. Two castings are shown in Fig. 8, to indicate the arrangement of the overflow and gate. On one of these a small runner may be seen above the down-gate, and it is also indicated in Fig. 5. The purpose of this was to indicate when to stop pouring, and thus prevent undue waste of metal. The steel solidified in the spiral first and then in the down-gate, while that in the basin was still fluid. Hence the steel builds up on top of the down-gate, and so flows along the runner which may be observed through a hole.

Cast No.	Composition, per cent.				Temperature, deg. C.	Distance. In.
	C.	Si.	Mn.	P.		
P 16 ..	0.35	0.72	0.65	0.06	1,570	14
P 17	0.55	0.59	0.80	0.066	1,515	11
P 18					—	9½
P 19					—	3

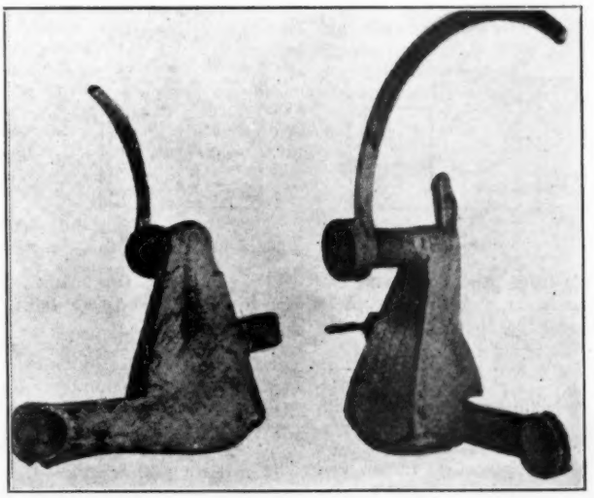


FIG. 8.—CASTINGS, SHOWING ARRANGEMENT OF OVERFLOW AND GATE.

Procedure Adopted

The weight of the metal melted was always 25 lbs., which served for two castings, and for

(*Continued on page 362.*)

D

Design of Sheet and Cast-Iron Parts for Vitreous Enamelling*

By J. H. COUPE

The art of vitreous enamelling is now on a definitely scientific basis, and calls more and more for thought and skill in the working of the metals to be treated. There is a real and growing tendency on the part of designers to take an intimate interest in essentials governed by the wide range of modern enamelled products of high quality. It is proposed, in this Paper, to consider, as an example, the group of requirements in the design of an electric cooker, which is, at the moment, enjoying a popular demand.

Both cast and sheet iron are used in this cooker. The working of these metals in this case is not so widely different from the conditions relating to other enamelled articles, and it is hoped that this Paper will be of general interest.

Considerations of Primary Importance

The first requirement in the production of good castings is that of the iron, and to produce this, high-quality pig-iron, good scrap and best foundry coke are necessary. A mixture for a highly successful charge has been given by the author in a previous Paper, but the analysis shown in Table I gives even more satisfactory results.

The foundry yard should be planned to facilitate careful mixing and weighing of the charge, as upon this depends the suitability of the castings. The coke is a most important factor, and should be as free from sulphur as possible.

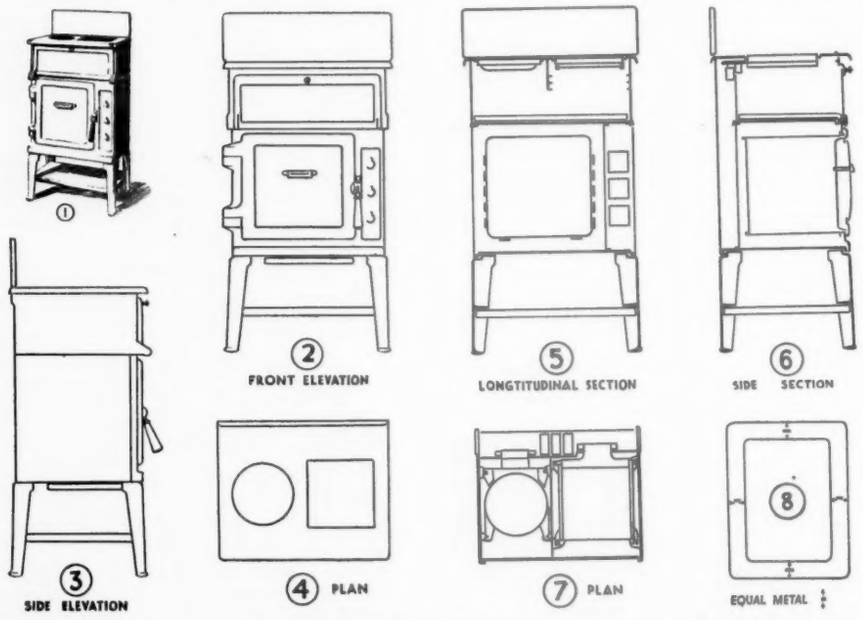
The plate patterns used must have carefully arranged runners and gates, to prevent sand being washed into the mould, which gives rise to trouble when enamelling. The object sought is to produce a casting which requires no filling before enamelling. These remarks will be readily appreciated by those who are called upon to enamel castings that are not of good quality, and which have previously been, say, stove-blacked. A badly enamelled casting is not necessarily caused by the enamel, but is invariably due to either bad design or faulty processing in the foundry.

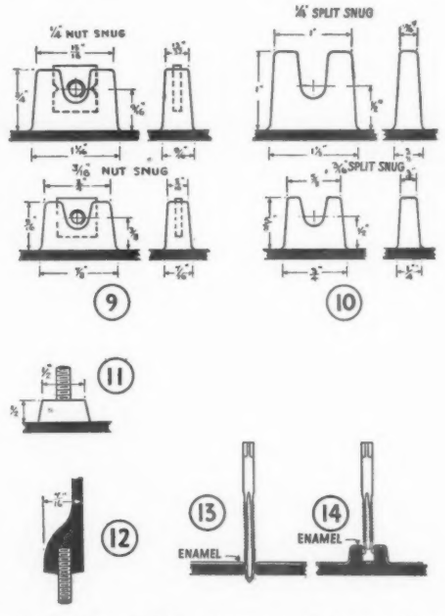
TABLE I.—*Composition and typical charge of a suitable mix for enamelling iron.*

Silicon	3.0 per cent.
Manganese	1.0 per cent. max.
Sulphur	0.02 to 0.04 per cent.
Phosphorus	1.0 to 1.1 per cent.

Charges for a 2-ton cupola.

	Cwts.	qrs.	lbs.
Coke	0	3	20
Pig-iron	7	2	0
Heavy scrap	1	2	0
Light scrap	6	0	0
Limestone	0	1	8





In order to obtain the best results, the designer must have a thorough knowledge of all the various processes of manufacture, such as pattern-making, foundry practice and sheet metal fabrication.

The Drawing Office

It is the usual practice of the designer primarily to make small sketches of what he hopes his final arrangement to look like. Such a sketch is shown in Fig. 1. These sketches are more easily appreciated if drawn in perspective. Having, by these means, arrived at a satisfactory article of proportion and utility, he will then lay out upon the drawing board, in as large a scale as possible, three views of his design:—Front elevation (Fig. 2), side elevation (Fig. 3) and plan (Fig. 4).

Having arrived at a stage when the final appearance is at its best, longitudinal, cross sections, and sectional plan can be drawn. These are shown in Figs. 5, 6 and 7. Following upon this comes the consideration and drawing of detailed parts. In laying out drawings for the workshops, as much information as possible must be given. Very often a perspective view of a part will enable a workman to obtain a better idea of what is intended. When giving dimensions, those of major importance must be distinctively marked. Drawings should be sufficiently clear in every detail, in order that the patternmaker and other workers can follow them easily. This will save the designer a considerable time in unnecessary verbal explanations. A good job is worthy of a good set of drawings. An intelligent workman will appreciate these, and his efforts will be better in consequence.

Dimensions must be clear and complete, and where a number of small dimensions combine to make a total, the overall should be given as a check on the others. It is the practice even today, with some designers, to draw out a few sections, from which patterns and then castings are made without any consideration being given to component parts. This casual method greatly increases costs, owing to many alterations which may be necessary. The rectified faults which occur very often mar the utility and general appearance of the finished article.

It will be appreciated from these remarks that arrangements drawn to show these component parts in position enable the patternmaker to visualise clearly what is required, and make due tolerance for easy and correct assembling.

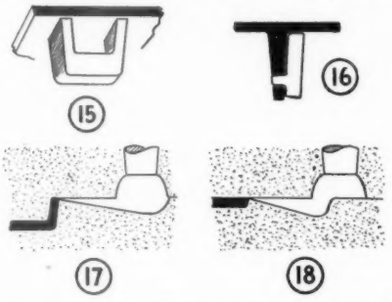
Design of Cast-Iron Parts

During the consideration of various details, it must be borne in mind that easy moulding,

* A Paper read before The Institute of Vitreous Enamellers, Mr. V. C. Faulkner presiding.

including sufficient taper, rounded corners and edges, is essential to produce a suitable casting for good enamelling. The ideal sought is a casting of even thickness and balanced proportions, to prevent unequal strains being set up, and to allow the enamel to fuse evenly over the whole surface. In some cases, the design will be thrown out of balance by force of circumstances, but this can be helped by the skilful use of webs or flanges. However, caution is essential in these cases.

All corners, edges and tops of flanges must have a radius of not less than $\frac{3}{16}$ in. to be consistent with good enamelling. A design incorporating this provision will have a very pleasing

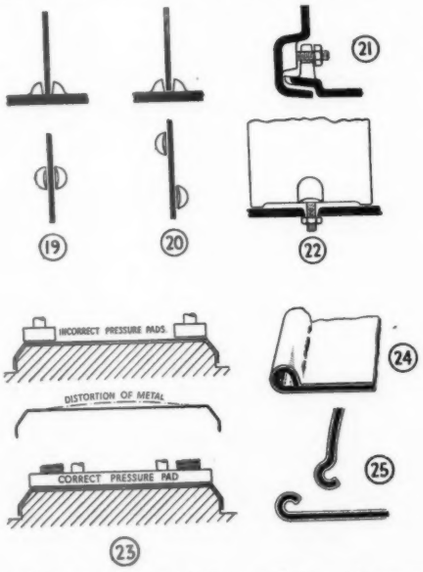


appearance, and will encourage the enamel to flow to the edges, without burning-off or crazing at the corners. Large holes in castings should be placed in such a position that, as nearly as possible, there is an equal amount of metal on all sides. This is shown in Fig. 8.

Cast-in Parts

In modern design, it is the practice to conceal all screws and fixing parts. The appearance of the finished article largely depends upon this. The article is obviously kept clean much more easily if no screw heads appear on the surface. It is the usual practice, in the light-castings industry, to cast in screw shanks and nuts for the sake of economy. In dealing with these, the following remarks should be helpful.

Lugs, bosses, etc., should be as light as is practicable. This will obviate castings from



drawing or sinking at these points, and prevent boiling marks appearing on the enamelled surfaces. Figs. 9, 10, 11 and 12 show lugs, bosses, nut snugs and cast-in shanks.

The dimensions given may be taken as standard for the light-castings trade. Dealing with the method of casting screw shanks in bosses, this is not always advisable, especially in cases where the particular surface is enamelled on the same side that the screw shanks are cast in. This is shown in Fig. 12. The difficulty arising is that the enamel flows round the threads, making it impossible to fit nuts without being forced to re-die. This method has not been found so economical as drilling before enamelling and tapping afterwards, even if the screw has been protected with clay, or by other known means.

If the holes in castings be tapped before enamelling, similar trouble arises, owing to the enamel flowing into the threads. When a hole has been drilled through a casting, and enamelled afterwards, it will be seen from Fig. 13 how easily it may be tapped by the use of a full taper tap. The plain nose of the tap acts as a reamer upon entering the hole, thus clearing away the enamel before the thread starts cutting. This definitely preserves the life of the tap. In Fig. 14, where a blind hole has been decided upon, the same thing takes place, except that a plug tap is used, which has been specially treated by grinding away the first two or three threads.

The same remarks apply to nut snugs when the enamel is likely to get into the thread of the nut. It is advisable, and more economical, for the cast-in nuts to have plain holes. The nut-snug, and split lugs, are, of course, standard practice. Simple cores can be utilised with advantage, to lighten heavy bosses, such as is shown in Fig. 15.

Chilling bosses and lugs, thus densening the metal, prevent porosity, which is another good practice where drilling and tapping are not required. This is shown in Fig. 16. The design of gates and runners, embodied in a plate pattern, to mould a channel for the metal to flow into the casting mould, plays a very important part in obtaining good-quality castings for enamelling. Runners and gates are shown in Figs. 17 and 18. Gates should be wide, and scored to a minimum thickness at the point of joining the casting; they may then be easily knocked off without risk of fracture to the casting. Two typical runners are shown in Figs. 17 and 18, and it will be noticed the heavy slope downwards away from the casting checks sand washing during the flow of metal.

The designer must also consider the moulding sand, and remember that narrow fragile bodies are liable to be washed away during the flow of metal, resulting in the casting filling up at these points. Figs. 19 and 20 illustrate a case in point. Two small pips are required to hold a piece of sheet metal in position. These may be staggered, to remove the objectional feature described.

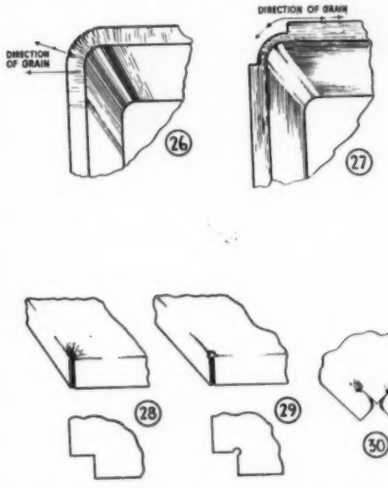
The designer must allow full tolerance for the thicknesses of enamel to ensure easy assembling. It is most difficult for the assembler successfully to remove surplus enamel from recesses, corners, etc., to enable parts to come snugly together. As an aid to easy assembling, fitting pips and strips, such as are shown in Figs. 21 and 22, can be used to advantage. These should be placed in an accessible position, so that they can be trimmed, if necessary, to adjust mechanical variations. All plain holes should have a fairly large clearance and the use of oval or slotted holes, when possible, is to be recommended.

Designing Sheet-Metal Parts

The designer should specify the most suitable iron to produce the desired results. A good-quality ingot iron, owing to its increased ductility, should be used where intricate bending, folding or pressing is required. Inferior iron causes an increased number of rejects in these cases. Cheaper grades of iron, however, can be used in other cases. Sheet metal is usually cut-up on guillotines, and passed to the press shop or sheet metal working departments, for further operations. The designer should remember that much saving of scrap can be effected by cutting standard sheets to the best advantage. Scrap cannot always be avoided, but such scrap should be used for smaller parts whenever possible.

Tools, where necessary, should have suitable pressure pads and stripping plates, to prevent any distortion of the metal. Such an arrangement is shown in Fig. 23. All tools must be kept in good condition. Close co-operation between the designer and the tool room is necessary if good enamelling is to be obtained. Metal should not be overworked, and all bends, folds, etc., should have easily rounded corners.

The question of gauge is important; when uncertain which gauge to use, choose the heavier, and judge each case upon its merits when deciding. Although there is no set standard, it is

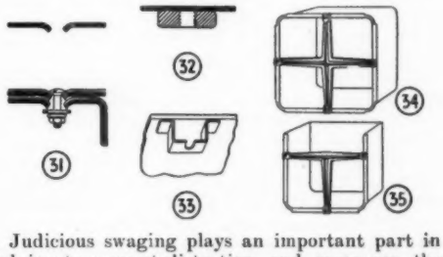


a good principle to assume that the larger the job, the heavier will be the gauge. When designing and making press tools for deep-drawn articles, it is essential to allow sufficient tolerance to avoid ironing and puckering of the metal, which is detrimental to enamelling.

Rolled edges should be avoided. Owing to the impossibility of producing an air-tight roll, acid percolates in during the pickling operation, and cannot be eliminated. This, coupled with the expansion of air in the roll when fusing, causes the enamel to bubble, as shown in Fig. 24. This particularly applies when the roll is a complete circle, as, for example, a sheet-metal lamp reflector, and even in the case of a straight roll it is not a practical proposition. Fig. 25 shows two successful alternatives.

Bending Considerations

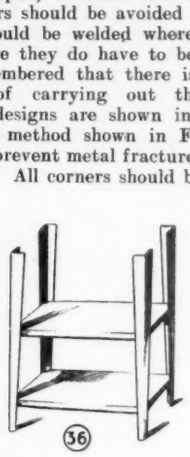
In seeking to obtain a first-class enamelled job, the designer must be prepared not only to design the part or article to suit enamelling, but also on occasions to design special tools or bending machines, in order to fashion the special shapes required for the particular job in mind.



Judicious swaging plays an important part in helping to prevent distortion, and, moreover, the direction of distortion can be definitely controlled by this means. There is a right and wrong way of bending metal. It is advisable, under all circumstances, to work the metal with the grain, that is, the direction in which the metal has been rolled. Fig. 26 shows what is meant by this. It illustrates a right-angle bend rolled round a corner, which imposes so great a strain on the metal at this point that it is liable to fracture, or to go out of alignment when being fired, if wrongly cut. Even when correctly rolled, this particular bend causes trouble if not treated as illustrated in Fig. 27. It will be noticed that

the point of the flange, where most strain occurs, has been cropped, to assist this operation.

Open corners should be avoided as far as possible, and should be welded wherever practical. In cases where they do have to be employed, it must be remembered that there is a right and wrong way of carrying out this operation. Appropriate designs are shown in Figs. 28, 29 and 30. The method shown in Fig. 29 uses a small hole to prevent metal fracture at the corner when folding. All corners should be cropped out



with a suitable tool, and on no account should shears be used. Fig. 30 demonstrates what happens, and it will be readily appreciated that good enamelling in this instance would also be impossible.

All holes and apertures, irrespective of size, should be treated as in Fig. 31. A $\frac{3}{16}$ in. radius inwards will encourage the enamel to flow right up to the edge. This will present no difficulties, with screw holes, during assembly, even in the case where it is desired to screw two sheets together in close proximity. The hole in the inner sheet should be a size larger than in the other sheet. All raw edges should be concealed.

Welding

Oxy-acetylene and electrical resistance welding are used, and a few points are well worth considering here. Cleanliness is essential to a good weld. All rust or loose scale must be removed, or burning and pitting will take place. Metal which is burnt in welding will rarely enamel, even if the part is ground and buffed afterwards. The top coat will run away from such parts, and thus expose the ground coat. When spot-welding, the electrodes should be kept trimmed to ensure good results, and the spots must be sufficiently close, to prevent the two pieces opening up between the welds during fusing the enamel. Close attention in the welding department is essential to secure a well-finished product, for there are many instances where a job well-designed in all other respects would suffer if welding were not intelligently done.

In cases where it is desired to attach concealed fixing screws on the underside of the enamelled sheets, it is not good practice to weld on tapped pieces of heavy-gauge metal, as the enamel will not fuse satisfactorily at these places, owing to excessive thickness of metal. This point is illustrated in Fig. 32. A light sheet saddle, similar to that shown in Fig. 33, is preferable from an enamelling point of view. A headed screw can be slipped into the slot, after enamelling, and nutted down. This saddle should be made of a lighter gauge metal than that of the part to which it is being welded. Channels and angles, welded on sheets of any *size*, are undesirable, as distortion will occur.

Folded flanges that are necessary to strengthen sheet metal should never be less than $\frac{3}{8}$ in. deep, and where holes are desired in a flange a depth of $\frac{1}{2}$ in. or more, according to the size of hole, is required, to prevent the hole breaking through the edge. Large notches and holes that would weaken the flange, must be avoided. Any strain at these points will be transmitted to the surface of metal, and result in damage to the enamel. All sheet metal parts, when ready for enamelling, must be rigid, to obtain the best results, and the use of special fixtures, designed with a view to increase this rigidity, is an aid to checking distortion. Figs. 34 and 35 show two shells where no tie exists between the walls, and fixtures overcoming the distortion which would otherwise occur.

It is well known that thin enamel is less likely to chip, and the enameller will keep the enamel coating as thin as possible, comparable with good results; but as there is always a tendency for the enamel to thicken at the edges, the designer should make an allowance of not less than $\frac{1}{8}$ in. for fitting. This applies particularly to work that has been swilled. Cases where enamel can accumulate in a corner whilst draining must be controlled with special care.

Development of Built-up Units

This modern practice should be employed whenever possible. Apart from rigidity, it is more economical. In designing units of this type, allowance must be made for correct expansion of the various welded parts. In Fig. 36 is shown a typical example of a satisfactory unit of this description which is made up of six parts spot welded together. It should be remembered that expansion takes place in all directions, and the design should be as evenly balanced as possible.

Enamelling

Wherever chipping or hair-lining are likely to occur on the edges of enamelled sheet parts, brushing down to the ground coat is a successful feature in correct design. Brushing not only overcomes these troubles, but in many cases improves the finished article from a decorative point of view. Where two parts are required to fit closely together, both surfaces should be brushed, particularly when such pieces fit against cast-iron surfaces. Parts should be so designed, and full arrangements made, for easy and efficient firing, that is, to provide holes in suitable positions for hanging, etc. The designer should, at all times, bear in mind the enamelling equipment from an economical point of view.

Assembling

Having arrived at the final stage for production, assembly is the next concern of the designer. All the previous remarks have paved the way for easy assembling, but one final point that must be considered is shock, to which the finished product is subject during handling and transit. Many enamelled articles chip and spoil after leaving the works; this is caused by bad design. These risks can be reduced to a minimum by the use of shock-absorbing washers, etc., at points where the shock is likely to do most damage. Chipping does not always occur at the point receiving the shock; the strain may be transferred to any rigidly screwed sheet parts. Washers to be recommended are the countersunk, asbestos aluminium-cased type; they produce a strong solid job, with sufficient give to absorb any imposed shock.

Assuming that the designer has a complete knowledge of the foregoing requirements, he is in a position to create an article of originality, utility, and pleasing appearance, and to make marked improvement from an engineer's point of view.

In presenting this Paper, it may be thought that the author has diverted on occasions to workshop practice, but in his opinion the one is essential to the other. In conclusion, he would like to acknowledge the help given by his colleagues on the staff of Belling & Company, Limited, who have collaborated with him in compiling this Paper.

Modern Tendencies in Vitreous Enamelling

PRODUCTS OF THE INDUSTRY CRITICISED

At the technical session of the Third Annual Conference of the Institute of Vitreous Enamellers, about 100 members assembled under the chairmanship of Dr. J. W. Mellor, F.R.S. (President of the Institute), to hear a Paper read by Mr. S. Hallsworth entitled "Modern Tendencies in Vitreous Enamelling." This was printed in the vitreous enamelling supplement of the October 8 issue of THE FOUNDRY TRADE JOURNAL.

At the conclusion of his Paper, MR. HALLSWORTH remarked that with regard to the subject of milling he could quite understand some people saying he had changed his opinion; but there was a saying that, "A wise man will change his opinion sometimes; a fool never." There was a time when he was in favour of the English practice of one-third of stones, and one-third of frit. He remembered Mr. R. W. Whittle stating that they should not keep to the same opinion too closely, but should try out the suggestions made at the meeting, and then return with a statement as to the results they had achieved. He had tried this method, and found it worked successfully.

Trivial Transfers!

MISS DOVE said that Mr. Hallsworth should not have dismissed transfers as an incidental. She considered that they were very important to the vitreous enamelling trade as a whole; in fact, they were worthy of a Paper to themselves, and when she had time to spare she intended to write one.

Enamel Drying Times

MR. C. P. STONE congratulated Mr. Hallsworth very sincerely upon the excellence of his Paper. Although the author had referred to what he had termed fantastic figures, they were not fantastic at all, but hinged round control. He (the speaker) was a keen advocate of control in every section of vitreous enamelling work, and in a previous Paper he had made a similar plea for such control to obtain the results mentioned in Mr. Hallsworth's Paper. He had had actual experience of the figures quoted by Mr. Hallsworth in working operation. With regard to the doubt concerning the ground-coat drying in $2\frac{1}{2}$ mins., it was common knowledge that if a good job in ground coat was required, it was drained and put on hot bars. It certainly dried in $2\frac{1}{2}$ mins., and was usually a first-class job. From his own experience, which was considerable, he had always found that a rapidly-dried ground coat always gave the best results.

Degreasing

Dealing with the question of degreasing, and the relative merits of trichlorethylene as a degreaser and other chemical degreasers, Mr. Stone said in his experience a combination of both was best. He had never found the trichlorethylene satisfactory inasmuch as the oil had a bad habit of draining into a corner where it was not desired. By starting with the one and completing with the other, satisfaction ensued. He certainly favoured their use in preference to the old methods of "grease burning." Unless acid descaling was used it was a difficult matter to clean by pickling.

Rapid Drying

MR. W. S. GRAINGER observed that he was very envious when he heard statements that so many thousand pieces were dealt with an hour. It was ideal when dealing with running lines; but when handling the variety of articles which

some enamellers had to tackle, it was very difficult to take advantage of the modern tendency to use conveyors and the like. A little more information with regard to rapid drying would be acceptable. He asked if the expression implied high temperature or facilities for air to circulate round the pieces and evaporate the water more quickly. In the old-fashioned type of hot chamber an attempt to have a high temperature in the dryer, and thus dry in a short space of time, would probably give rise to trouble. Had Mr. Hallsworth experienced rapid drying with fine white enamels or those containing any preparation such as gum?

Drying Time Materially Reduced

Mr. Hallsworth admitted that, with regard to grip-coat drying, the method was hot-air drying, or products of combustion, plus re-circulation of the products of combustion and hot air. It used to take five minutes to dry the grip coat, and it was desired to increase the production of the apparatus. The experts said it could not be increased because the drying could not be done in less than five minutes without trouble. On inspecting the dryer for some other purpose, however, it was found that the pieces were dry before they were three-quarters of the way round. The speed of the conveyor was increased and the drying operation now occupied 2½ minutes. White enamels could safely be dried in 3½ minutes with a similar system. It was mainly a question of the circulation of heat. He had not experienced rapid drying with fine enamels or enamels containing gum. He was of the opinion that even the jobbing enameller could design mechanical means for the purpose of increasing production output, though possibly not of the type described in the Paper. It might be done by adjusting the carriers, or by designing a different unit altogether. He felt sure that mechanisation would be of service to the jobbing enameller.

Temperatures Used

Mr. Grainger asked at what temperature the stove was controlled. Furthermore, he would appreciate advice regarding some method of dealing with a plate of a particular section, and also a reflector, the contours of which he indicated.

Mr. Hallsworth replied that he had dealt with certain table tops which were similar. They were now able to put them on the conveyor without marking them. The temperature was about 480 to 500 deg. Fah.

Mr. Stone remarked, with regard to ground-coat drying, that he had been very successful in drying in seven minutes in a temperature of re-circulated air at 180 deg. Fah.

Mr. Grainger asked at what temperature the dried work left the oven.

Mr. Hallsworth replied that it was approximately 358 deg. Fah., although it was difficult to state the exact temperature.

An External "Grouse"

Mr. F. Mileson, speaking as a visitor, expressed his appreciation of the excellence of the Paper. He would like to hear of a works manager who was not suffering from the enameller. The people who supplied the enameller with apparatus, such as furnace builders and conveyor makers, were all doing something to overcome the troubles of enamelling; but, unfortunately, it was found that the enamellers themselves were doing very little. All the mechanical handling plants and schemes which were devised for controlling the labour in an enamelling department reduced the great cost which the enamelling department had to carry, because of an excessive amount of scrap. He had had experience of the same batch of material being melted, and milled at the same time; identical pieces of metal fused in the furnace, yet similar results were not obtained. Inconsistency was one of the greatest problems the enamelling industry had to solve, and he hoped to hear something regarding the solution of this difficulty.

The President thought that inconsistency applied to every other industry.

Scrap Reduction and Rhythmic Working

Mr. R. W. Whittle said that certain views had been expressed with regard to organisation and control, and one speaker had asked how it was possible to eliminate scrap. He was reminded, a few weeks ago, that 40 years had passed since he, the speaker, had signed his indentures of apprenticeship, and he had been trying to discover how to eliminate scrap throughout that period. The President had suggested that the only way to discover such a method was in the establishment of a research department. Each problem had to be approached with an outlook free from bias. That day he had visited the works of the Pilkington Tile & Pottery Company, and quite recently he had visited certain workshops in Germany, and it was a coincidence that the Germans had introduced the same methods into their factories as were practised by the Pilkington Company for the purpose of accelerating their mass production in cases where mechanisation was impossible. They had introduced the gramophone and the wireless, and it was surprising to find how rhythm of movement increased the output of the workers.

Control Surpasses Research in Importance

Mr. Hallsworth said that the chief reason for the introduction of mechanical units was to increase the production per operator per hour. Raising of quality was of importance also. He spoke somewhat diffidently himself, being a chemist, but he felt that control was even more important than research work for the purpose of reducing scrap. A system of control throughout the whole process of enamelling would bring about reduction of costs, including the steel, the foundry and the enamelling shops. With a first-quality steel, or first-quality ingot iron, there was very little scrap, but higher prices had to be paid for the material. The reason for the higher price was that the buyer had to pay the cost of the method of control adopted by the manufacturer. The manufacturer of cheap steel or iron had not to incur that on-cost. In the foundry, castings of exactly the same analysis were produced, yet in the enamelling shop variations became apparent. There would, of course, always be troubles in connection with intense mechanisation as well as with slight mechanisation, but if someone saw that the castings were cast under strict control, they would enamel quite easily. The more a control system could be perfected, the more the scrap would be eliminated.

Price and Quality

Mr. Stone said that Mr. Mileson had touched upon one of his favourite subjects. The question was not so much one of metal as of control and design. There was insufficient collaboration between the designer and the enameller. Most of the present large scrap heaps were due to three things: lack of control, poor design, and the use of enamels that were not quite suitable for the job.

A great deal was heard about ingot iron, which was a very nice material to work with, but, if the design were right, C.R.C.A. steel would make a four-five job, which for many purposes was just as good. Nevertheless, if really excellent white work were required, ingot iron should always be used. Unfortunately, the question of price was often a matter of importance.

Mr. W. H. Whittle agreed with the points which had been raised respecting design and control. The price factor, of course, had always to be allowed for. Greater speed of output was desirable, but it would probably carry along with its advantages certain disadvantages. When consumers desired a really first-class article, a definite specification was usually supplied. The price, of course, would be higher, but the scrap would be proportionately lower.

Furnace Design

Mr. A. England said that one thought which had occurred to him was the very slight modification of some of the new methods compared with the old ones. It was not many years since everybody was saying there must be oil-fired furnaces. They had an illustration that afternoon of an American furnace which was more or less of the Dressler type. He suggested that many of the methods which had been tried out in recent years had been introduced by outsiders and not by practical enamellers. These outsiders gave wonderful illustrations of what their appliances could do. If vitreous enamellers would collect their rejects, and classify them according to the methods of production, probably some very useful information would result from the investigation and a great advance would be made in the industry.

Mr. Hallsworth said he must differ a little from Mr. England in his views regarding muffles. The change-over to the oil-fired muffle was not because someone had wished to sell an article, but because the oil-fired muffle was considered to be an improvement on the old coal-fired type and gave much better results. Since then there had been a further development of the coal-fired muffle, and the system now in vogue was much different from the one which formerly obtained. It had been really a question of process rather than a matter of exploitation.

Mr. England also differed from Mr. Hallsworth with regard to the coal-fired furnace. There were members present who worked an almost similar type of furnace, thirty years ago, to the regenerative furnaces which were on the market to-day.

Mr. Hallsworth insisted that his remarks had summed up his own experience. With the old-type coal-fired furnace, the combustion was in the fire-box, but in the new type gas was produced and burnt in the combustion chamber.

Coal Economy

Mr. Grainger said that the type of furnace Mr. England was speaking about burned sixteen to eighteen tons of coal per week as contrasted with the modern furnace referred to by Mr. Hallsworth, which only consumed seven to eight tons.

Mr. Stone thought that the point had been missed with regard to the change from coal to oil, which had been necessitated by the introduction of wet enamelling on cast iron. The old under-fired furnaces were not capable of being controlled to the temperature required; therefore, oil was used in the same kind of furnace, and the amount of oil burned determined the temperature. The modern over-fired or Dressler type of furnace had overcome the trouble, and simple adjustments by any temperature required could be obtained at any time. It was in 1927 when the change took place, and that was with the introduction of the wet process.

Dealing with the question of price and quality of enamel finish, unless a high standard of quality was maintained it would probably be found that some other kind of finish would result. The qualities of enamel should be beauty of appearance and long life, and, in his opinion, a very large section of the general public would be prepared to pay the price to obtain them. The majority of English people objected to buying an article the good appearance of which disappeared in a few weeks or months.

Pyrometric Control

Mr. J. H. Coupe observed that pyrometric control of furnaces had resulted in a considerable reduction of rejects. He thought the success of a mechanised plant largely depended upon the type of products and their quantity. It was quite feasible to mechanise a plant for repetition products. When there was great diversity of products, the mechanised plant failed to cope with them. He installed plant some years ago for the production of electric cookers when he

produced only one type. Eventually he was making seventeen models simultaneously, and to run a plant of that description economically it would be necessary to put down seventeen shops in order to mechanise the processes.

Conveyorised Systems

MR. HALLSWORTH remarked that he still thought it was a question of design. He believed that a conveyor could be designed which would carry the components of seventeen different cookers. What was necessary was to have the correct type of drier and the correct type of conveyor to deal with the various articles. The firm with which he was associated made a large number of cookers of different sizes. It might be a little more difficult to deal with a large sign plate, or something of that description, but it was quite feasible in the case of normal size pieces, say, three or four feet square in area. Different shapes could be dealt with on the same unit.

MR. COUPE said he had recently visited one of the largest enamelling shops in this country where a mechanical gas-fired drier was installed, similar to the one in Mr. Hallsworth's factory. The economy of that plant largely depended upon whether it was fed with castings that were sprayed before being put into the drying chamber. A gentleman connected with the firm wanted to show him at what speed this could be done, but, unfortunately, the casting did not come from the sand-blast chamber to the spraying chamber in time to be put on the conveyor. He was of opinion that there must be a continuous system in order to have economical working of a conveyor plant. In America, extremely expensive conveying plants had been installed, and the capital cost was a very important consideration.

Elasticity of Design

MR. HALLSWORTH said that the number of pieces which could be fed into the drier could be increased to about 4,000 or 5,000 per hr. if they were of a suitable type. It was definitely possible to swill 700 to 1,400 pieces of any shape or size within an hour.

MR. COUPE said he knew that in America conveying plants were employed in the enamelling industry which had never earned the money it had cost to instal them.

MR. HALLSWORTH asked if Mr. Coupe thought the initial design, on the introduction of the plant, was wrong.

MR. COUPE said it depended upon the amount to go through the particular process.

Variety Introduces Difficulties

MR. STONE agreed with Mr. Coupe, but he thought Mr. Hallsworth was speaking from a different angle. In the case of a gas-cooker plate it was quite easy to use the conveyor, but in the case of the electric cooker, owing to the multiplicity of parts and intricate shapes, it was not so easy. Also, in the case of the gas cooker there was the additional advantage of an extremely heavy flow of work which did not vary in character as would be the case with electric cooking apparatus. This would probably be the reason why, in the old hand-operated shop, the majority of electric cooking materials were dealt with in the night-time, when there was more room and opportunity to do the intricate shapes. The enamelling of a gas-cooker plate could be timed accurately.

MR. W. TODD observed that it was merely necessary to design the interior of electric ovens in order to adapt mechanical methods of handling, thus emphasising Mr. Stone's earlier plea that greater consideration be given to the design of appliances from an enamelling viewpoint.

MR. STONE agreed that it could be done, but supply authorities had laid down rules in regard to one piece ovens from which manufacturers were not allowed to depart.

Rapid Deterioration of Enamelled Ware

MR. H. W. WHITTLE said that since it had been his privilege to be connected with the Institute he had visited a number of works and observed the modern tendency with regard to vitreous enamelling which he admired very much indeed. He had always endeavoured to bear in mind that such modern methods were intended to produce large quantities of enamelled articles, at the same time maintaining first-class quality; unless these methods did this they would lose much of their value. He was pleased to hear Mr. Stone stress the point of quality. When going through the factories, of course, one saw the articles as newly made, and when they were of beautiful appearance. His experience was that after use some of those articles did not preserve their attractive appearance. He was disappointed with some of the enamelling. Every endeavour should be made to produce enamelled articles which would maintain the beauty of their original appearance, otherwise the danger which Mr. Stone had alluded to of some other finish being introduced was likely to become an accomplished fact.

Transfers—*Ultra Vires*

MR. HALLSWORTH remarked that he had not fully answered Miss Dove's point regarding the term "incidental." He would like to point out that that word, when used in connection with the transfers, was used when speaking of the Robot-like machine unit, where a plate could be put in as it was pressed, and would come out complete with transfer. He had not really dealt with transfers, because the Paper was dealing more or less with modern tendencies in enamelling practice; not with modern tendencies in beautifying a cooker, etc., by the use of transfers.

MISS DOVE thought transfers were a subject for a future Paper.

MR. HALLSWORTH agreed.

MR. W. H. WHITTLE said he would bear that point in mind.

Upon the motion of MR. GRAINGER, a vote of thanks was accorded to Mr. Hallsworth for his excellent Paper.

Oxidation Control for Firing Ground-Coat Enamels*

By W. G. MARTIN

When a piece of iron is cleaned, covered with ground coat, dried, and placed in the furnace, it begins to oxidise almost immediately. It is, of course, generally recognised that oxygen from the air in the furnace can very readily penetrate through the ground coat between the particles of frit. As the temperature of the iron rises, the oxidation takes place more and more rapidly. Temperature is the major factor, while denseness of ground coat and thickness of iron oxide layer seem to play minor rôles in determining the speed of oxidation. There are other factors which will be mentioned later. Under ordinary practice, oxidation is stopped by only one thing, and that is the fusion of the ground coat to form a blanket to exclude oxygen.

Function of the Iron Oxide Layer

Experiments have shown that an ordinary ground coat enamel, carrying the usual amount of cobalt, will have very poor adherence to ordinary pickled iron if it is fused to that iron in an atmosphere free from oxygen—in this case the usual iron oxide layer cannot form. In fact, the bond is so weak that the enamel may raise up from the iron in many, usually round, spots, leaving the iron silvery bright and absolutely free from any glass. If, however, the ground coated iron is held for long periods, at, say, 590 deg. C. in air, an iron oxide layer between the enamel and base metal is formed, which is so thick that the enamel cannot dissolve it during firing and very poor bond is the result.

With ordinary practice, the iron oxide layer reaches approximately the correct thickness by the time the ground coat fuses, which occurs at about 597 to 640 deg. C. As the temperature rises higher, the enamel dissolves the iron oxide. It seems that the ordinary ground coat glass is so changed by the addition of the iron oxide that its wetting power, or ability to adhere to the iron, is vastly improved. Of course, there is also more etching of the iron surface, more area exposed when the oxide layer is formed and dissolved, and this produces what is called a mechanical type of adherence.

The importance of the iron oxide layer is therefore apparent, but unfortunately there are a number of variables affecting its proper formation. These are:

(1) Rate of temperature rise of ware—
  (*a*) Influenced by furnace design;
  (*b*) Influenced by gauge of ware;
  (*c*) May be variable within the range.
(2) Total time before fusion of the enamel.
(3) Denseness of ground coat.
(4) Oxidation characteristics of the iron.
(5) Iron oxide dissolving characteristics of the ground coat.

Copper-heading and Fish Scaling

It is thought that when a shop has copper-heading, or the type of fish scaling caused by poor bond, the trouble is caused by the variation of one or more of the above factors. A copperhead is the direct result of excessive local oxidation, the causes of which vary periodically. Since good bond and certain defects are definitely related to oxidation, it is then highly desirable to produce a correctly formed oxide layer. In order to do this, the iron oxide producing part of the enamelling operations should be separated from the fusing part, so that the oxidation can be subjected to proper control. Also, there are certain advantages to be gained by fusing in the absence of oxygen, and this forms another equally important reason for separating and more carefully controlling the steps of oxidation and fusion.

When the oxidation step is made independent of the fusing, two things can be done; a proper temperature can be selected at which most of the oxide is formed, and the amount of time allowed for oxidation can be lengthened. A considerable amount of experimental evidence proves that uniformity will result if the oxidation takes place more slowly. This seems to be very beneficial in equalising variations in oxidation characteristics, not only from sheet to sheet, but in regard to difference in small areas on the surface of the same piece of iron. There has been a number of instances where a definite and surprising decrease in fish scaling has been encountered using controlled oxidation as compared to ordinary firing. Of course, not all types of fish scale, nor fish scaling from other causes, could be eliminated by controlled oxidation firing.

Passive Iron

It has been observed that some iron is quite passive to oxidation as a result of hydrogen annealing. This passivity is broken down gradually, and it is concluded that when any area of an iron surface is reluctant to oxidise, a slower

(*Continued on page* 362.)

* A Paper presented before the American Ceramic Society. The Author is director of enamel research, A. O. Smith Corporation, Milwaukee, Wisc.

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and longer oxidation treatment will tend to bring up to normal the final amount of oxide formed on this area.

If the oxidation step is separate from the fusing operation, the time and temperature of oxidation can easily be changed to conform properly to changes in gauge, type, or surface characteristics of the metal, or changes of enamel. It is hardly necessary to add that, with present practice, there is little that can be done to modify the oxidation step once it has been fixed by furnace design, enamel formula, and enamel milling. Furthermore, these factors should be set to suit their own functions best, and not changed to aid some other operation.

After the iron has been properly oxidised, it must be heated to the maturing temperature of the ground coat and held there long enough to allow most of the iron oxide to dissolve in the glass, or, generally speaking, it must be held at that temperature until this coat is properly fired. There are several reasons why it is desirable to fuse the enamel in the absence of oxygen. In the first place, in the temperature range, 597 to 815 deg. C. and higher, the iron will oxidise very rapidly if oxygen can come into contact with it. When the iron is at a dull red heat, the enamel is still melting and the gases released are blowing small bubbles in the viscous glass.

The enamel then does not immediately form a blanket which can be depended upon to keep oxygen away from the iron. There is considerable time at high temperature when oxygen can gain access to the iron through openings in the partly fused enamel coating. Conditions will be worse if foreign matter in the enamel, on the iron, or in the iron is producing gas and thus blowing holes in the coating through which oxygen can enter. When the oxygen enters, the iron oxide formed is very likely to be in excess of the desirable amount. If the enamel can dissolve it, well and good, but if this solution produces additional gassing, or if the original cause of the local disturbance persists, it is probable that an excess of iron oxide will be formed. The result of the excess iron oxide will be a copper-head, or perhaps if the enamel was able to cover the oxide, a fish scale will be produced.

Reboiling Experiments

Another reason for fusing the enamel in an oxygen free atmosphere is that ground coat so fired does not reboil. To check this point, small samples approximately 3 by 5 in. were sheared from various sheets of iron. The samples were stamped so that they could be carried through the operations in pairs which had been adjacent to each other in the larger sheets. Through cleaning, pickling, dipping, and drying, the treatment was identical, then, one of each pair was fired according to standard practice, in air. The other one of the pair was oxidised in air at approximately 540 deg. C. and was then fused in an oxygen-free atmosphere. Usually such samples are aged a few days to accentuate any reboiling tendency which may occur. When such pairs of samples are given the standard reboiling test, it is always found that the sample fused in an oxygen-free atmosphere does not reboil to any appreciable extent even though its mate fired in air may reboil badly.

It is thought that considerable quantities of various gases, such as oxygen, can, under certain conditions, dissolve in iron and steel. It is also probable that the amount of oxygen present in the enamel is somewhat variable. Professor Louis Kahlenberg has said that the laws of exact proportions in chemistry cannot always be relied upon. He feels that the SiO_2 in silicates should often be more correctly labelled SiO_x. There are therefore two places where the oxygen can be absorbed, and it seems that this gas causes reboiling since the trouble can almost be eliminated by fusing the ground coat in an oxygen-free atmosphere. Another advantage to be had when oxygen is eliminated lies in the very considerable lessening of burning off at edges. The effect is noted consistently. The explanation probably lies in the fact that the enamel at the edges cannot protect the iron from oxidation at the higher temperatures. This same mechanism allows the successful application of a thinner ground coat, and it is thought that a thin ground coat is beneficial to the general quality of second coats, as well as to the general strength of the ware.

Oxygen Control

In the laboratory it is convenient and economical to use cylinders of nitrogen or carbon dioxide. These gases can be led into the fusing chamber through simple plate orifices, so that the proper amount of gas to exclude air may be duplicated from time to time. It is not necessary to analyse the gas in the fusing chamber. A piece of pickled iron, fired where oxygen has been excluded, may be bent 90 degs. as soon as it is cool and no bond will prove the absence of oxygen. The flow of gas may be restricted for successive samples until some bond results and a slight increase on this will be the correct supply for the set-up.

For commercial use compressed gases would, of course, be too expensive. The cheapest raw material is air, and almost any fuel such as coke, oil, manufactured gas, natural gas or butane, can be burned to combine with the oxygen and thus eliminate it as such. There are on the market several makes of machines which automatically proportion the fuel and air, burn the mixture, and cool the products. The fuel cost for producing the atmosphere would be approximately one halfpenny per hundred pounds of 20-gauge iron. With any common fuel except coke, considerable amounts of water vapour will form when the oxygen combines with the hydrogen from the fuel. This water can readily be condensed out by cooling the gases. In fact, on warm humid days after cooling, the products of combustion will carry less moisture than did the air used.

Glass-Lined Tanks

Some ground coats are very susceptible to water vapour in the fusing chamber. The action is evidenced by a rough or orange peel surface which may be so severe as to cause a similar surface on the cover coat. It is suggested that the possibility of reducing the moisture to a fair and constant amount regardless of weather should be a worth-while advantage. The rôle of water vapour during the firing of ground coats is not yet fully understood, but there is ample evidence that it is an important factor.

The author's company specialises in the larger sizes of glass-lined tanks, diameters up to twelve feet and lengths to forty feet. They are all welded one-piece tanks and must be fired as such. These naturally involve certain problems, and perfection of the ground coat is highly desirable. Whilst the company does not produce many square feet per day as compared to other enamel shops, opportunities often occur to study anywhere from 1,000 to 1,700 square feet of enamel in one piece, and it has been found that the use of controlled oxidation principles has been of great value in this work. Controlled oxidation has also been used in development work which falls in a class between the laboratory and the shop. Special enamels are used for most of this work, and it should be pointed out that the ground coats are not as workable as the commercial ground coats because it has been necessary to incorporate certain characteristics such as low solubility with some sacrifice of workability. Using controlled oxidation, results in general should be even better with more workable enamels—tolerances should be greater, but certain of the benefits of controlled oxidation may not be so readily apparent, except when troublesome combinations of iron and enamel are encountered. Virtually all of the company's work has been done on iron other than enamelling stock, and very considerable savings have been made possible by the use of this method on the lower cost iron or steel, and it is thought that there is considerable opportunity for any enamel shop to reduce costs in this way.

When the ground coat is fired without preoxidation and in the absence of oxygen, little bond is formed on a pickled iron. If the same iron is sand-blasted and so fired, the bond is quite good. Such work has resulted in a distinction being made between the mechanical bond of a sand-blasted surface and the wetting power bond of a fairly smooth pickled surface. The same bond may be obtained whether the iron oxide is introduced by oxidising the iron either before or after enamelling, by milling it into the slip, or by smelting it into the frit.

Conclusion

In conclusion, the most important points will be stated.

Sufficient iron or other suitable metallic oxide must be introduced into the ordinary ground coat, so that proper adherence will be possible.

The metallic oxide must be introduced uniformly. If this oxide is made by oxidising the iron, a mean temperature of, say, 540 deg. C. is recommended, so that the layer will be uniform and more exactly controllable in amount.

When the enamel is fused in the absence of oxygen excess oxide cannot form over the ware generally, or locally.

Ground coats fired in the absence of oxygen do not reboil. This should be of particular value where only one coat cover is to be used.

Thinner ground coats may be used because burning off of edges and burning through at thin spots will be very materially reduced.

Savings may be effected by:—(*a*) Using thinner ground coats; (*b*) having less defective ground coat ware; (*c*) making one cover coat practical; (*d*) using sheet iron purchased carefully, but not purchased as enamelling stock.

Second Report of the Steel Castings Research Committee

(*Continued from page* 355.)

each composition two tests were obtained at temperatures varying by about 50 deg. C. by waiting for a short time between the two castings. The temperatures were taken by two different tungsten-molybdenum couples with a portable potentiometer, so that readings were obtained to 0.01 mV., or to 1 deg. C.

In the case of the silicon alloys, it was found that the silicon showed a tendency to float on the surface, thus causing differences in composition of the melt. These alloys were accordingly melted in the high-frequency induction furnace. The mould was kept stationary, and the steel was cast *via* a small runner previously heated to about 1,200 deg. C. to prevent chilling.

Two examples of the records showing the working periods are given below, and are representative of all the casts:—

Started	9.10 P.M.	
Charged	10.10	21½ lbs. of boiler plate scrap.
Melted	11.40	Added 1¼ ozs. of silicon metal and 3 lbs. of Swedish white iron.
	12.20 A.M.	Added 8 ozs. of manganese metal.
Cast	12.35	
Charged	12.45 A.M.	17 lbs. of boiler plate scrap.
Melted	2.15	Added 1¼ ozs. of silicon metal and 3 lbs. of Swedish white iron.
	3.0	Added 5½ lbs. of manganese metal.
Cast	3.50	

Programme of Work

It was decided first of all to determine the relation between fluidity and casting temperatures for Armco iron, after which the separate elements were to be dealt with in turn. The following systems have thus been considered:—

Iron-carbon.
Iron-phosphorus.
Iron-silicon containing 0·4 per cent. of carbon.
Iron-manganese containing 0·5 per cent. of carbon.

Ternary alloys will also be dealt with. Tables of results are given in Part II.

(*To be continued.*)

CUMMING'S BLACKINGS
ARE
THE BEST

Extract from daily report by one of our travellers:—

January 9th, 1936.

Mr. C..... said,

"I shall send on to you every time. Since we adopted your Blacking the skin of our castings has improved by 100 per cent. Our customers were the first to notice it."

NEED WE SAY MORE

All our productions are carefully graded, tested and manufactured.

WM. CUMMING & CO., LTD.

KELVINVALE MILLS, Maryhill, Glasgow, N.W.
SUNNYSIDE BLACKING MILLS, Falkirk.
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STATION CHAMBERS, Middlesbrough.

The Week's News in Brief

Trade Talk

VICKERS-ARMSTRONGS, LIMITED, of Newcastle, has resumed production at its foundry, which has been closed for seven years.

LEYLAND MOTORS, LIMITED, Leyland, Lancs, have received an order for 125 passenger vehicles from the Central S.M.T. Company, Limited, Motherwell.

JOSEPH & EDWARD BATES & SONS, LIMITED, brass-founders and safe and steel-furniture manufacturers, of Wolverhampton, propose to make considerable extensions to their works and offices.

THE DELEGATION representing German ex-Service-men's organisation, which visited this country recently, were entertained by the Austin Motor Company, Limited, Longbridge, on October 27.

HARLAND & WOLFF, LIMITED, Govan, have received an order for a passenger motor liner from the Government of Western Australia. The machinery will be constructed at the firm's Finnieston Works, Glasgow.

CHARLES CONNELL, LIMITED, of Scotstoun, have received an order for two cargo liners for J. & J. Denholm, Limited, Glasgow. Messrs. Rankin & Blackmore, Limited, Greenock, will provide the machinery.

A SECTION OF THE WORKS of Herbert Morris, Limited, Loughborough, is being extended, and on completion will cover an area of about seven acres under one roof. The new works are scheduled to be in operation within the next six months.

THE TENDER by Richardsons, Westgarth-Brown Boveri, Limited, West Hartlepool, for a turbo-alternator for Portobello power station, Edinburgh, at a cost of £89,218, has been recommended for acceptance by Edinburgh Corporation.

THE ANNUAL CHEMICAL DINNER will be held in the Wharncliffe Rooms, Great Central Hotel, Marylebone, London, on November 19. Prof. A. G. Green, M.Sc., F.R.S., will be in the chair, and the chief guest will be Sir Gilbert T. Morgan, O.B.E., D.Sc., F.R.S.

A PULP MILL EVAPORATING PLANT constructed by Henry Balfour & Company, Limited, of Leven, in conjunction with George Scott & Company, Limited, London, was shipped to Russia last week. The plant, which is the largest of its kind constructed in one unit, has been made to the order of the U.S.S.R.

ALLIED IRONFOUNDERS, LIMITED, has acquired practically the whole of the share capital of General Gas Appliances, Limited, with a view to developing the present production of gas cookers, gas fires, and other gas appliances. Messrs. W. R. Francis and S. C. Whitheld will continue as joint managing directors of General Gas Appliances, Limited, which is a private company.

THE ENGLISH STEEL CORPORATION, LIMITED, and Cammell Laird & Company, Limited, announce the issue of further capital to finance extensions. The English Steel Corporation is issuing deferred ordinary shares for cash on the basis of three new shares at par for every deferred share held. The amount involved is £848,340. Ordinary stockholders of Cammell Laird & Company, Limited, will be asked to authorise the issue of 800,000 additional shares of 5s.

THE LONDON & NORTH EASTERN RAILWAY COMPANY has placed a contract with the United Steel Companies, Limited, for 30 tons of steel fishplates, and 4,000 pairs of wagon wheels and axles have been ordered as under :—John Baker & Bessemer, Limited, Rotherham, 1,000 pairs; Taylor Bros. & Company, Limited, Manchester, 2,000 pairs; Owen & Dyson, Limited, Rotherham, 1,000 pairs. In addition, 770 tons of permanent-way chairs have been ordered from Smith, Patterson & Company, Limited, of Blaydon-on-Tyne, and 1,000 tons of pig-iron from J. C. Abbott & Company, Limited, Birmingham.

BIRMETALS, LIMITED, a subsidiary company of Birmid Industries, Limited, have recently purchased a large estate at Woodgate, near Quinton, and building operations have commenced for the construction of an up-to-date works. The lay-out, including laboratories and offices, will cover approximately 310,000 sq. ft., and will be equipped with the latest design of rolling-mill plant, extrusion presses, electric furnaces, electrical and mechanical plant, etc., for the production of high-tensile aluminium and magnesium alloy sheets, also extrusions and drawn sections in the same alloys. A large metallurgical and physical laboratory will be built adjacent to the works.

Personal

MR. W. MORRIS is director and general works manager of the Anderston Foundry Company, Limited, Port Clarence, and not managing director as was stated last week.

MR. AND MRS. JOHN BELL, of Hamilton, last week celebrated their golden wedding. Mr. Bell retired a fortnight ago from his employment with Hurst, Nelson & Company, Limited, Motherwell.

MR. ERIC REA, County Agricultural Organiser for Gloucestershire, has been appointed agricultural adviser to the board of directors of R. A. Lister & Company, Limited, Dursley, and of its associated firms.

MR. J. M. COLVILLE, a director of David Colville & Sons, Limited, has been appointed a member of the Scottish Committee of the Council for Art and Industry, in place of Mr. W. S. Draffen, who has resigned.

MR. LEWIS CHAPMAN has resigned from the board of the Birmingham Small Arms Company, Limited, as his whole time is required by the increased activity of the steel companies in the B.S.A. group. Mr. Chapman is managing director of William Jessop & Sons, Limited, and J. J. Saville & Company, Limited, both of which are controlled by B.S.A., Limited.

GOLD MEDALS were presented last week to employees of Glenfield & Kennedy, Limited, Kilmarnock, who have completed 50 years' continuous service with the company. They include Mr. Alex. McCaw, patternmaker, aged 70, and Mr. R. Hutchison, moulder, aged 64. Mr. E. Bruce Ball made the presentations. The number of medals presented by the directors since 1930 is now 37.

Obituary

MR. ROBERT BIRTWISTLE, who died last week at the age of 70, was head of the business of S. S. Stott & Company, Laneside Foundry, Haslingden, Lancs.

MR. ROBERT POLLOCK, of Renfrew, died recently at the age of 78. He was for over 30 years employed as a patternmaker by Babcock & Wilcox, Limited.

THE DEATH OCCURRED, on October 28, of Ex-Bailie Allan McLymont Ure, chairman and managing director of Allan Ure & Company, Limited, ironfounders, of Glasgow. Mr. Ure, who was in his 69th year, was the originator of the " back-to-back " fireplace.

MR. JOHN MCEACHEN, who was for 59 years connected with Cameron & Roberton, Limited, Southbank Ironworks, Kirkintilloch, died at Salt Spring Island, Victoria, British Columbia, on October 17. He was moulding-shop foreman for 40 years, and retired in July, 1935, when in his 73rd year. In the early part of this year he went to Canada to visit his family, who had all emigrated some years ago. Mr. McEachen, who was one of the early workers with semi-steel, became associated with Prof. Campion in his experimental work on the use of oil-sand cores, and he and Prof. Campion were joint authors of a Paper presented to the Manchester conference of the Institute of British Foundrymen in 1923. Three years ago he reorganised the foundry of Cameron & Roberton in order to produce Meehanite metal. He took an active interest in the work of the Scottish Branch of the Institute of British Foundrymen, and served on the Council for some years.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Foster Bros. (Preston), Limited, Hope Foundry, Lancaster Road, Preston.—Capital, £10,000. Engineers and ironfounders. Directors: J. Foster, F. J. Foster and S. R. Aldrich.

Salmon Whitfield & Company, Limited, Victoria Works, Kettering Northants.—Capital, £2,000 in £1 shares. Ironfounders, manufacturers of gas-producing plants, etc. Directors: C. Whitfield and K. W. Willans.

Contracts Open

Barnstaple, November 16.—10-ton overhead crane, for the Town Council. Preece, Cardew & Rider, 8 and 10, Queen Anne's Gate, Westminster, S.W.1. (Fee £2, returnable.)

Holbrook, November 14.—620 yds. of 3-in. spun-iron pipes, for the Belper Rural District Council. Elliott & Brown, Burton Buildings, Parliament Street, Nottingham. (Fee £3 3s., returnable.)

Oldham, November 10.—665 18-in. iron pipes, 12 ft. long, class D, and 630 16-in. ditto, class C, made to B.S.S. No. 78, 1917, for the Town Council Waterworks Department. Mr. E. Parry, commercial manager, Gas and Water Offices, Greaves Street, Oldham.

Sherborne, November 16.—1,146 yds. of 4-in. cast-iron water main, for the Urban District Council. Mr. C. E. Bean, water engineer, Council Offices, Sherborne. (Fee £2 2s., returnable.)

Sittingbourne, November 12.—Four miles of 12-in., 10-in. and 9-in. cast-iron mains, for the Urban District Council. A. P. I. Cotterell & Son, 54, Victoria Street, Westminster, S.W.1. (Fee £5 5s., returnable.)

Walsingham, November 16.—8½ miles of 6-in., 4-in. and 3-in. cast-iron mains, for the Walsingham Rural District Council. Mr. A. E. Kerrison, clerk, Council Offices, Fakenham, Norfolk. (Fee £3 3s., returnable.)

Company Reports

Glenfield & Kennedy, Limited.—Interim dividend of 5 per cent. on the ordinary shares.

Stanton Ironworks Company, Limited.—Interim dividend on the ordinary shares of 4 per cent.

Lancashire Steel Corporation, Limited.—Interim dividend on the ordinary capital of 1½ per cent. on account of 1936.

Brown, Bayley's Steel Works, Limited.—Two years' dividend on the 5 per cent. cumulative, tax free, preference shares, discharging the arrears to July 31.

Company Meeting

The annual meeting of Lightalloys, Limited, was held in London on October 28, CAPT. OLIVER LYTTELTON (chairman) said that the current year's trading has been highly satisfactory, and the prospects for this continuing for the remainder of the year were good. The order-book on September 30, 1936, was more than twice as big as it was at the same date last year. This increase had made it neccssary to add to the plant.

Forthcoming Events

Institute of British Foundrymen

NOVEMBER 7.

Lancashire Branch :—" Foundry Refractories," Paper by W. J. Rees, M.Sc., at the Engineers' Club, Albert Square, Manchester, at 4 p.m.

NOVEMBER 9.

Lancashire Branch :—Works visit to the Staveley Coal & Iron Company, Limited, near Chesterfield.

NOVEMBER 10.

Lancashire Branch (Burnley Section) :—" Making a Core-Drum in Green Sand," Paper by G. Dewhurst, and " The Melting and Casting of Non-Ferrous Metals," Paper by R. Hargreaves, at the Municipal College, Ormerod Road, Burnley, at 7.15 p.m.

NOVEMBER 14.

Scottish Branch :—" Mould and Core Washes at Atmospheric and Elevated Temperatures," Paper by R. F. Hudson, at the Royal Technical College, Glasgow, at 4 p.m.

Wales and Monmouth Branch :—" Some Technical Observations on the Production of Cast Iron," Paper by J. H. Williams, at the Technical College, Newport.

West Riding of Yorkshire Branch :—" Dimensional Tolerances for Castings with Particular Reference to Malleable Cast Iron," presented by F. K. Neath, B.Sc., at the Technical College, Bradford, at 6.30 p.m.

The Institute of Vitreous Enamellers

NOVEMBER 11.

Southern Section :—" Elements of Costing, with Particular Reference to Vitreous Enamelling," Paper by J. Peddar, at the British Industries House, Marble Arch, London, W.1, at 8 p.m.

NOVEMBER 12.

Northern Section :—" Development of Airless Shot Blasting," Paper by H. Boardman, at Queen's Hotel, Manchester, at 7.30 p.m.

THE "ROCKET" CORE MAKING MACHINES

HELP to . . .

REDUCE COSTS AND MAKE SOUND CASTINGS

for

BRITISH

— STEEL FOUNDERS —
GREY IRON FOUNDERS
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used in the manufacture of—

Electric Cookers. Gas Cookers. Motor Transport Vehicles. Aeroplanes. Internal Combustion Engines. Cast Iron Bath Fittings. Brass Water Service Fittings. Sluice Valves. Gas Valves. Rain Water Castings. Textile Machinery. Lawn Mowers. Ship Building, etc., and General Engineering Castings.

FOUNDRY ENGINEERS LIMITED

HALIFAX — YORKS.

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Raw Material Markets

In existing circumstances new business in the iron and steel industry continues to be restricted to very small parcels. Production of steel has been considerably retarded by the lack of pig-iron supplies, while the inability of makers to secure adequate tonnages of ore and coke does not allow any expansion in the output of hematite; in fact, one furnace on the West Coast has been compelled to cease operations. In some cases producers of hematite are charging premiums of from 5s. to 10s. per ton on top of the standard rates. The system of import licences for iron and steel came into operation this week.

Pig-Iron

MIDDLESBROUGH.—Owing to the acute shortage of supplies of Cleveland foundry iron deliveries under existing contracts have fallen into arrears. At the present time there is only one furnace engaged on the production of Cleveland iron, but it is expected that a new blast furnace at Skinningrove will be in operation within a short time. Producers are adopting a system of distribution under which all consumers receive supplies according to their requirements, and while this method of rationing is by no means ideal, it is generally acknowledged to be the best in view of the conditions now prevailing. Prices are unchanged, but when quotations next come under review a substantial increase is likely to result. Meanwhile, quotations are almost nominal, the standard No. 3 Cleveland G.M.B. quality being invoiced at 75s. per ton Middlesbrough and Falkirk, 77s. on the North-East Coast, and 78s. on Clydeside.

Following the cessation of operations at a furnace which was engaged on the manufacture of hematite at Workington, consumers have transferred their attention to the East Coast, but their efforts to secure supplies have met with little success. Export trade is negligible. Prices are unchanged and, as yet, makers here have refrained from imposing premiums. Fixed minimum home prices of East Coast mixed numbers are 85s. on the North-East Coast, 90s. 6d. in Sheffield and 96s. in Birmingham, all less 5s. per ton rebate.

LANCASHIRE.—Activity among the light-castings and machine-tool trades continues to be on a good scale, and the demand for foundry iron from these sources is heavy. Most consumers of pig-iron in this area have now covered their requirements over a considerable period, although current business is still substantial. Offers of Derbyshire and Staffordshire brands of No. 3 iron are quoted, for delivery in the Lancashire price zone, on the basis of 83s. per ton, with Northamptonshire at 81s. 6d., and Derbyshire forge iron at from 78s. to 80s. There is an excellent demand for hematite. Offers of West Coast material are on the basis of 93s. 6d., including delivery to Manchester, with East Coast at 93s., both subject to a rebate of 5s. per ton. Scottish foundry iron is quoted at around 93s. per ton.

MIDLANDS.—Northamptonshire brands of iron remain the most popular in this area, but other grades also receive a large number of inquiries from local ironfoundries. Producers of Northants No. 3 iron have sold their outputs up to the end of March, and so there are virtually no sellers of this material at the present time. Supplies of Derbyshire iron, however, are comparatively easily obtained. There have been no changes in the prices of Midland brands of foundry iron, and the figures delivered Birmingham and Black Country stations are 77s. 6d. for Northamptonshire No. 3 and 80s. for Derbyshire, Lincolnshire and North Staffordshire No. 3. An extra 11d. per ton is charged if delivered into works, and there is a small sliding-scale rebate to large consumers. There is a moderate demand for forge pig-iron, the price of which remains at 5s. per ton below No. 3 foundry if required for puddling purposes, but only 3s. less if used in the foundries. Firm conditions continue to prevail in the market for special irons. The general engineering and jobbing concerns are well placed for work, and their requirements of special grades are expected to expand steadily. Prices are as follow:—Medium-phosphorus, 82s. to 90s.; low-phosphorus, 92s. 6d. to 100s.; refined iron, £6 10s., minimum. Scottish No. 3 is quoted around 92s. 6d., delivered the Midlands. Several makers of hematite are demanding premiums over and above the standard rates for all future transactions. Any new business that is accepted only involves deliveries up to the end of February. Some producers are right off the market and do not quote prices. The official minimum Association prices are £4 16s. for East Coast No. 3, £4 17s. for West Coast mixed numbers, and £4 15s. 6d. for Welsh mixed numbers, delivered stations in this area or 1s. 6d. per ton more if delivered into works.

SCOTLAND.—Deliveries of pig-iron in this area are satisfactory, but reports indicate that there has been a slight decrease in activity during the past week. Prices are unchanged at 81s. 6d. for No. 1 and 79s. for No. 3 foundry f.o.t. furnaces. There continues to be a good demand from makers of light castings, who are very busy. Quotations for No. 3 Cleveland foundry iron are nominal at 75s. f.o.t. Falkirk and 78s. f.o.t. Glasgow, while No. 4 foundry is 1s. per ton less. Steelmakers remain very active, and there is no alteration in quotations for steel-making irons, which are 85s. 6d. for mixed numbers of East Coast, West Coast and Scottish hematite, less 5s. rebate; basic, British and Indian, 75s., less 5s. rebate, all f.o.t. steelworks here. Shipments of Indian basic continue to arrive in substantial tonnages and are readily taken up by local users.

Coke

There is little change to report in the condition of the foundry-coke market, which remains very firm. No change has been made in prices which, for delivery in Birmingham and district, are 40s. to 42s. 6d. for best Durham qualities, with Welsh from 40s. to 50s. per ton.

Steel

Busy conditions continue to rule in the steel market, says the official report of the London Iron and Steel Exchange. In one or two departments the volume of trading has been less active owing to the fact that consumers have largely covered their forward requirements, and the producers have filled their order-books for as far forward as they care to sell. In most sections of the market, however, a considerable volume of new business is offering in the shape of supplementary parcels from consumers who under-estimated their requirements when contracting for supplies earlier in the year. There is a heavy request for semi-finished steel, and the producers, although they are operating at capacity, are experiencing difficulty in meeting the requirements of the consuming industries. The position in this market, however, although tight, is certainly better than in the corresponding period of last year, when operations at many consuming works were interfered with. In the finished-steel section a high rate of output is being maintained. The requirements of the consuming industries, however, continue to increase, and heavy as the production is, it is barely sufficient to keep pace with the demand. The times required by the works for the execution of an order are lengthening, and it has become almost impossible to place orders for structural steel for near delivery.

Scrap

The market for iron and steel scrap in the Cleveland area continues to be keen. Pig-iron is very scarce, and the works are endeavouring to procure heavier supplies. For good, heavy steel scrap, 60s. per ton is now readily paid. Machinery cast-iron scrap is active at 67s. 6d., minimum, while there is a good demand for foundry cast-iron scrap at 65s. Only small tonnages are being taken up on the South Wales market, which is rather quiet at the present time. Heavy steel scrap is steady at 64s., while mixed wrought-iron and steel scrap in furnace sizes is active at 60s. to 62s. There is only a moderate demand for cast-iron scrap in large pieces and furnace sizes, but the value is firm at 59s. to 60s. A small local demand exists for good cast-iron machinery scrap for foundry purposes at 62s. 6d. to 65s. Prices are firm on the Midland market. Business is confined chiefly to small parcels for prompt delivery. Heavy unsheared wrought iron is at 65s. to 67s. 6d., while supplies of machinery metal broken into handy sizes are scarce at 72s. 6d. Short, heavy steel, as used in the foundries, is at 65s. to 67s. 6d. per ton, delivered works. Steady conditions are prevailing on the Scottish market, and some heavy tonnages have recently changed hands. First-quality heavy steel scrap is at 57s. 6d., with heavy basic, or heavy iron and steel scrap mixed, at 52s. 6d. Wrought-iron piling scrap is well taken up at 70s., with 72s. 6d. to 75s. for special material. Heavy machinery cast-iron scrap, in pieces not exceeding 1 cwt., is around 69s., while for ordinary heavy cast iron, to the same specification, 5s. per ton less is paid, delivered f.o.t. consumers' works.

Metals

The Reich Controller for base metals has announced a further restriction in the use of copper, nickel, lead, tin and their alloys in Germany. The armaments industry remains exempt from the decree, while articles manufactured for export also are not affected.

Copper.—Further activity has been witnessed in this market during the past week, and buying has involved substantial tonnages. The question on everybody's lips at the present time appears to be, "How high is copper going?" The price is now at the highest level for over five years past. In many quarters it is thought that the metal will be fetching £50 per ton in a short while. Over optimism is not good, and the situation will have to be studied carefully, but at the same time it would appear that everything favours a further advance in price. Some heavy buying is reported to have taken place in the United States following the recent price increase.

Daily market prices:—

Cash.—Thursday, £42 6s. 3d. to £42 7s. 6d.; Friday, £42 13s. 9d. to £42 16s. 3d.; Monday, £43 7s. 6d. to £43 8s. 9d.; Tuesday, £43 10s. to £43 11s. 3d.; Wednesday, £44 5s. to £44 7s. 6d.

Three Months.—Thursday, £42 11s. 3d. to £42 13s. 9d.; Friday. £43 to £43 1s. 3d.; Monday, £43 13s. 9d. to £43 15s.; Tuesday, £43 16s. 3d. to £43 17s. 6d.; Wednesday, £44 11s. 3d. to £44 12s. 6d.

Tin.—Conversation in tin circles at the present time is chiefly concerned with the outcome of to-day's (Thursday's) meeting of the International Tin Committee. Most people appear to be wearied of the tedious negotiations that have taken place during the past twelve months, and it is pleasing to know that some decision must be made before the end of this year. It is generally stated in Amsterdam that the scheme is as good as dead, while similar opinions are also heard elsewhere. An interesting view is expressed in the current weekly market report issued by Brandeis, Goldschmidt & Company, Limited. It is stated that "it does not seem to matter much to the market what happens at the meeting of the tin producers. If prices are kept unnaturally high by artificially decreasing production much longer, consumption will suffer severely, and substitutes and new sources of production will be further encouraged. As there is hardly any speculative bull account existing in tin at present, even the lapse of the present agreement may not have a very alarming effect immediately. It will no doubt make prices recede in an orderly way, which would be all to the good of the market. A fall in price seems to be inevitable in the long run."

Metal Exchange quotations were as follow:—

Cash.—Thursday, £206 5s. to £206 15s.; Friday, £209 10s. to £210; Monday, £208 to £208 5s.; Tuesday, £211 10s. to £212; Wednesday, £217 to £218.

Three Months.—Thursday, £204 15s. to £205; Friday, £207 15s. to £208; Monday, £206 5s. to £206 10s.; Tuesday, £209 17s. 6d. to £210 2s. 6d.; Wednesday, £214 10s. to £214 15s.

Spelter.—This market has again been rather quiet, and remains featureless. The demand is moderately good and consumption is satisfactory. Firm conditions are prevailing on the Continent. Interest in the Cartel negotiations appears to have dwindled to a minimum.

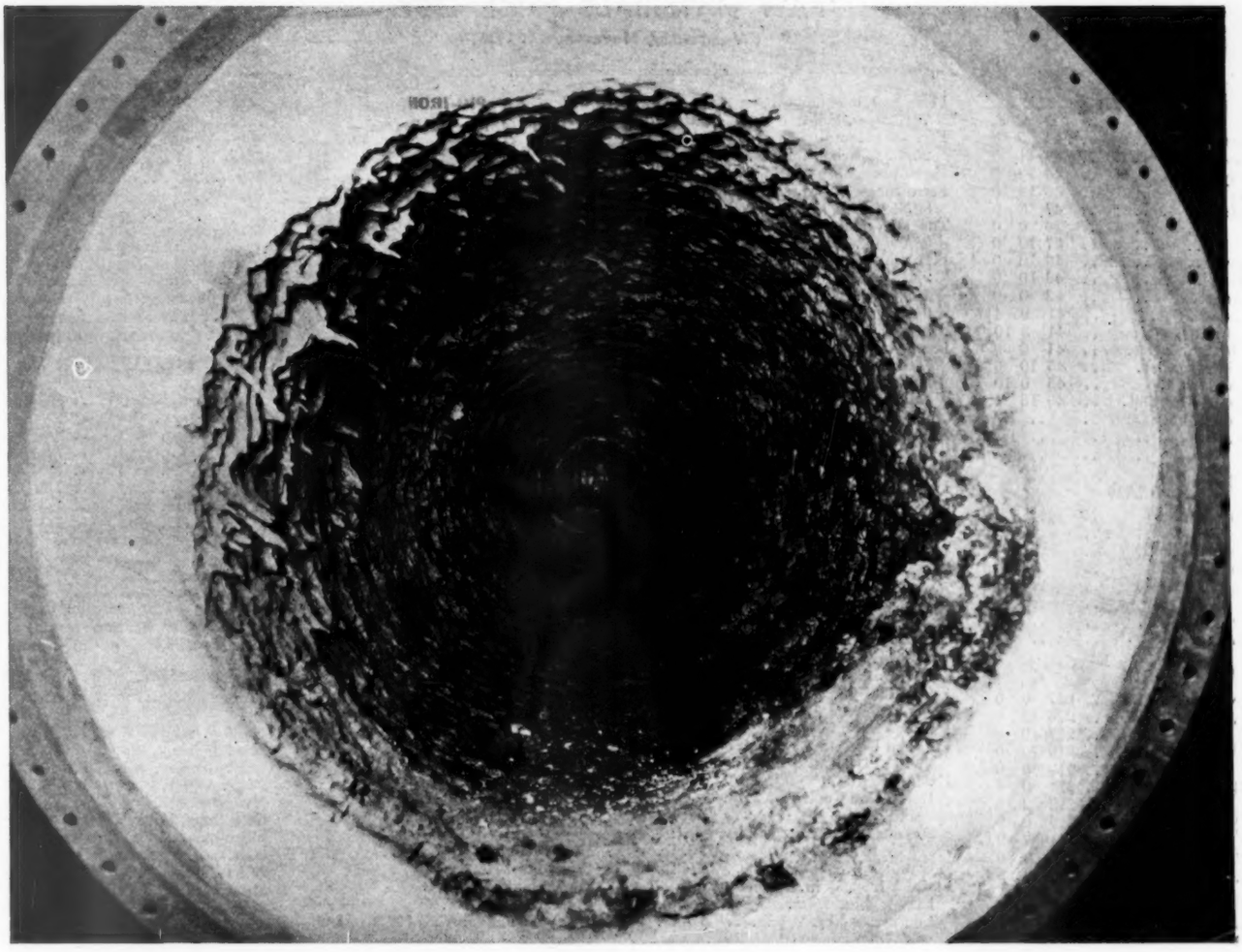
Official quotations were as follow:—

Ordinary.—Thursday, £15 3s. 9d.; Friday, £15 12s. 6d.; Monday, £15 17s. 6d.; Tuesday, £16 1s. 3d.; Wednesday, £16 5s.

Lead.—Prospects for lead-consuming industries are excellent, and the market continues its firm course. As far as Continental trade is concerned the chief sources of activity are to be found in France and Holland. The American Bureau of Metal Statistics states that lead production during September was 118,300 tons, as compared with 120,700 tons in August.

Day-to-day quotations:—

Soft Foreign (Prompt).—Thursday, £18 18s. 9d.; Friday, £19 10s.; Monday, £19 6s. 3d.; Tuesday, £19 17s. 6d.; Wednesday, £20 5s.



950 tons of metal melted—

The above photograph shows the condition of an 04 grade Albino lining in a 5-ton Brackelsberg furnace after 255 heats. You will observe the lining has worn back evenly and it is still approximately 8" in thickness. The 04 grade is specially produced for rotary furnaces, but there are other grades for lining cupolas, converters and ladles. This photograph is reproduced by courtesy of James Howden and Company (Land) Ltd.

ALBINO

ROTARY FURNACE LINING MATERIAL

Please write for further particulars to the sole manufacturers:

GENERAL REFRACTORIES LIMITED,

Genefax House, Sheffield, 10

Telephone: Sheffield 31113 (6 lines) Telegrams: "Genefax, Sheffield"

MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION.

RAW MATERIALS—PRICE LIST

(Wednesday, November 4, 1936)

COPPER

	£	s.	d.
Standard cash	44	5	0
Three months	44	11	3
Electrolytic	48	10	0
Tough	46	15	0
Best selected	47	5	0
Sheets	76	0	0
India	57	10	0
Wire bars	48	10	0
Ingot bars	48	10	0
H.C. wire rods	52	0	0
Off. av. cash, Oct.	41	0	4 1/2
Do., 3 mths., Oct.	41	3	10 1/4
Do., Sttlmnt., Oct.	41	0	5 5/11
Do., Electro, Oct.	45	10	6 3/11
Do., B.S., Oct.	45	0	10
Do., wire bars, Oct.	45	15	1 1/11
Solid drawn tubes			11 1/2d.
Brazed tubes			11 1/2d.
Wire			7d.

BRASS

Solid drawn tubes	10 1/2d.
Brazed tubes	12 1/2d.
Rods, drawn	9 1/2d.
Rods, extd. or rlld.	5 1/2d.
Sheets to 10 w.g.	8 1/2d.
Wire	8 1/2d.
Rolled metal	7 7/8d.
Yellow metal rods	5 1/2d.

TIN

	£	s.	d.
Standard cash	217	0	0
Three months	214	10	0
English	217	10	0
Bars	219	10	0
Straits	219	5	0
Australian	217	0	0
Eastern	212	2	6
Banca (nom.)	219	0	0
Off. av. cash, Oct.	201	7	3 3/11
Do., 3 mths., Oct.	199	2	0 6/11
Do., Sttlmt., Oct.	201	6	9 9/11

SPELTER

	£	s.	d.
Ordinary	16	5	0
Remelted	14	15	0
Hard	13	15	0
Electro 99.9	18	5	0
English	17	0	0
India	14	10	0
Zinc dust	19	15	0
Zinc ashes	4	10	0
Off. aver., Oct.	14	13	10 3/11
Aver. spot, Oct.	14	11	0 21/22

LEAD

	£	s.	d.
Soft foreign ppt.	20	5	0
Empire	20	12	6
English	22	5	0
Off. aver., Oct.	18	8	2 23/44
Aver. spot, Oct.	18	8	11 23/33

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£	s.	d.		£	s.	d.
Zinc sheets, English	25	0	0	to 25	10	0	
Do., V.M. ex-whse.	25	0	0	to 25	10	0	
Rods				28	0	0	

ANTIMONY

	£	s.	d.		£	s.	d.
English	67	10	0	to 68	10	0	
Chinese, ex-whse.				54	0	0	
Crude, c.i.f.				25	0	0	

QUICKSILVER

	£	s.	d.
Quicksilver	14	5	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—							
25%				8	17	6	
45/50%	11	0	0	to 12	5	0	
75%	16	2	6	to 17	7	6	
Ferro-vanadium—							
35/50%				12/8 lb. Va.			
Ferro-molybdenum—							
70/75% carbon-free				4/6 lb. Mo.			
Ferro-titanium—							
20/25% carbon-free				9d. lb.			
Ferro-phosphorus, 20/25%				£21 to £22			
Ferro-tungsten—							
80/85%				3/1 1/2 lb.			
Tungsten metal powder—							
98/99%				3/3 lb.			
Ferro-chrome—							
2/4% car.				33	0	0	
4/6% car.				21	10	0	
6/8% car.				21	0	0	
8/10% car.				21	0	0	
Ferro-chrome—							
Max. 2% car.				33	10	0	
Max. 1% car.				36	5	0	
Max. 0.5% car.				37	5	0	
70% carbon-free				9 1/2d. lb.			
Nickel—99.5/100%				£200 to £205			
"F" nickel shot				£184	0	0	
Ferro-cobalt, 98/99%				6/3 to 6/9 lb.			
Metallic chromium—							
96/98%				2/5 lb.			
Ferro-manganese—							
76/80% loose	£11	15	0	to 12	5	0	
76/80% packed	£12	15	0	to 13	5	0	
76/80% export				£10	15	0	
Metallic manganese—							
94/96% carbon-free				1/3 lb.			

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/4 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 3/16 in.	1/- lb.
Flats, 1/2 in. × 1/4 in. to under 1 in. × 3/8 in.	3d. lb.
Do., under 1/2 in. × 1/4 in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.		£	s.	d.
South Wales—							
Heavy steel					3	4	0
Mixed iron and steel	3	0	0	to 3	2	0	
Heavy cast iron	2	19	0	to 3	0	0	
Good machinery	3	2	6	to 3	5	0	
Cleveland—							
Heavy steel					3	0	0
Steel turnings					2	5	0
Heavy cast iron					3	5	0
Heavy machinery					3	7	6
Midlands—							
Light cast-iron scrap					2	15	0
Heavy wrought iron	3	5	0	to 3	7	6	
Steel turnings					2	0	0
Scotland—							
Heavy steel					2	17	6
Ordinary cast iron	3	4	0	to 3	5	0	
Engineers' turnings					2	2	6
Cast-iron borings					1	18	0
Wrot-iron piling					3	10	0
Heavy machinery					3	9	0
London—Merchants' buying prices, delivered yard.							
Copper (clean)					37	0	0
Brass					22	0	0
Lead (less usual draft)					18	0	0
Tea lead					13	0	0
Zinc					9	10	0
New aluminium cuttings					74	0	0
Braziery copper					33	0	0
Gunmetal					33	0	0
Hollow pewter					145	0	0
Shaped black pewter					110	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	77/6
,, No. 3	75/-
,, No. 4	74/-
Forge No. 4	74/-
Hematite No. 1	85/6*
Hematite M/Nos.	85/-*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/6*
,, d/d Birm.	97/-*
Malleable iron d/d Birm.	125/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	77/-
,, No. 3 fdry.	80/-
Northants forge	74/6
,, fdry. No. 3	77/6
,, fdry. No. 1	80/6
Derbyshire forge	77/-
,, fdry. No. 3	80/-
,, fdry. No. 1	83/-
Scotland—	
Foundry, No. 1, f.o.t.	81/6
,, No. 3, f.o.t.	79/-
Cleveland No. 3, Glasgow	78/-
,, ,, Falkirk	75/-
Scottish hem. M/Nos. d/d	85/6*
Sheffield (d/d district)—	
Derby forge	74/6
,, fdry. No. 3	77/6
Lincs forge	74/6
,, fdry. No. 3	77/6
W.C. hematite	91/-*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	83/-
Staffs fdry. No. 3	83/-
Northants fdry. No. 3	81/6
Cleveland fdry. No. 3	83/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	93/-
Clyde, No. 3	93/-
Monkland, No. 3	93/-
Summerlee, No. 3	93/-
Eglinton, No. 3	93/-
Gartsherrie, No. 3	93/-
Shotts, No. 3	93/-

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.		£	s.	d.
Bars (cr.)					10	10	0
Nut and bolt iron	8	17	6	to 9	7	6	
Hoops				11	7	6 and up.	
Marked bars (Staffs) f.o.t.				13	0	0	
Gas strip				11	7	6 and up.	
Bolts and nuts, 1/2 in. × 4 in.				16	0	0 and up.	
Steel—							
Plates, ship, etc.	9	7	6	to 9	10	0	
Boiler plts.	9	17	6	to 10	0	0	
Chequer plts.				11	0	0	
Angles				9	0	0	
Tees				10	0	0	
Joists				9	7	6	
Rounds and squares, 3 in. to 5 1/2 in.				10	0	0	
Rounds under 3 in. to 1/2 in. (Untested)				9	7	0	
Flats—8 in. wide and over				9	5	0	
,, under 8 in. and over 5 in.				9	10	0	
Rails, heavy	8	5	0	to 8	10	0	
Fishplates				12	10	0	
Hoops (Staffs)				10	2	0	
Black sheets, 24g. (4-t. lots)				12	0	0	
Galv. cor. shts. (,,)				14	0	0	
Galv. flat shts. (,,)				14	10	0	
Galv. fencing wire, 8g. plain				15	0	0	
Billets, soft				6	2	6	
Billets, hard	7	2	6	to 7	7	6	
Sheet bars				6	0	0	
Tin bars				6	0	0	

PHOSPHOR BRONZE

	Per lb. basis
Strip	10 1/2d.
Sheet to 10 w.g.	11 1/2d.
Wire	12 7/8d.
Rods	12 1/2d.
Tubes	14 1/2d.
Castings	12 1/2d.

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1 1/2 to 1/7 1/2
To 15 in. wide	1/1 1/2 to 1/7 1/2
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2 1/2 to 1/8 1/2
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3 1/2
Ingots rolled to spoon size	10d. to 1/6 1/2
Wire round—	
to 10g.	1/4 1/2 to 1/11 1/2

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3 1/2 upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.88
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37 1/2
Billets	32.00
Sheet bars	32.00
Wire rods	40.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	2.05
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.80
Steel hoops	1.95
Sheets, black, No. 24	2.60
Sheets, galv., No. 24	3.20
Wire nails	2.05
Plain wire	2.50
Barbed wire, galv.	2.55
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/- to 32/6
,, furnace	24/6 to 25/-
Durham foundry	24/6
,, furnace	21/6
Scotland, foundry	30/-
,, furnace	25/- to 26/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box		18/9
,,	28×20 ,,		37/6
,,	20×10 ,,		27/-
,,	18 3/4×14 ,,		19/6
C.W.	20×14 ,,	15/6 to	15/9
,,	28×20 ,,	33/9 to	34/-
,,	20×10 ,,	22/6 to	22/9
,,	18 3/8×14 ,,	15/3 to	15/9

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6	0	0	to £7	0	0	
Bars-hammered, basis	£16	0	0	to £16	10	0	
Bars and nail-rods, rolled, basis	£15	15	0	to £16	0	0	
Blooms	£10	0	0	to £12	0	0	
Keg steel	£25	0	0	to £28	0	0	
Faggot steel	£18	0	0	to £23	0	0	
Bars and rods dead soft, st'l	£10	0	0	to £12	0	0	

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£ s. d.	
Oct.	29 ..	42 6 3 dec.	2/6
,,	30 ..	42 13 9 inc.	7/6
Nov.	2 ..	43 7 6 ,,	13/9
,,	3 ..	43 10 0 ,,	2/6
,,	4 ..	44 5 0 ,,	15/-

Electrolytic Copper

		£ s. d	
Oct.	29 ..	46 10 0 No	change
,,	30 ..	47 0 0 inc.	10/-
Nov.	2 ..	47 10 0 ,,	10/-
,,	3 ..	48 0 0 ,,	10/-
,,	4 ..	48 10 0 ,,	10/-

Standard Tin (cash)

		£ s. d.	
Oct.	29 ..	206 5 0 inc.	15/-
,,	30 ..	209 10 0 ,,	65/-
Nov.	2 ..	208 0 0 dec.	30/-
,,	3 ..	211 10 0 inc.	70/-
,,	4 ..	217 0 0 ,,	110/-

Tin (English ingots)

		£ s. d.	
Oct.	29 ..	206 5 0 inc.	5/-
,,	30 ..	209 15 0 ,,	70/-
Nov.	2 ..	208 0 0 dec.	35/-
,,	3 ..	212 0 0 inc.	80/-
,,	4 ..	217 10 0 ,,	110/-

Spelter (ordinary)

		£ s. d.	
Oct.	29 ..	15 3 9 inc.	2/6
,,	30 ..	15 12 6 ,,	8/9
Nov.	2 ..	15 17 6 ,,	5/-
,,	3 ..	16 1 3 ,,	3/9
,,	4 ..	16 5 0 ,,	3/9

Spelter (Electro, 99.9 per cent.)

		£ s. d.	
Oct.	29 ..	17 3 9 inc.	2/6
,,	30 ..	17 12 6 ,,	8/9
Nov.	2 ..	17 17 6 ,,	5/-
,,	3 ..	18 1 3 ,,	3/9
,,	4 ..	18 5 0 ,,	3/9

Lead (soft foreign, prompt)

		£ s. d.	
Oct.	29 ..	18 18 9 inc.	5/-
,,	30 ..	19 10 0 ,,	11/3
Nov.	2 ..	19 6 3 dec.	3/9
,,	3 ..	19 17 6 inc.	11/3
,,	4 ..	20 5 0 ,,	7/6

Lead (English)

		£ s. d.	
Oct.	29 ..	21 0 0 inc.	5/-
,,	30 ..	21 5 0 ,,	5/-
Nov.	2 ..	21 5 0 No	change
,,	3 ..	22 0 0 inc.	15/-
,,	4 ..	22 5 0 ,,	5/-

AVERAGE MONTHLY PRICES OF DERBYSHIRE NO. 3 FOUNDRY AT MANCHESTER.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1900	4 0 0	4 0 0	4 0 0	4 1 6	4 1 0	3 18 0	3 13 6	3 12 6	3 11 0	3 11 0	3 9 6	3 8 0	3 15 5
1901	2 13 6	2 17 0	2 15 0	2 15 0	2 14 0	2 13 9	2 13 6	2 13 6	2 14 6	2 13 0	2 12 6	2 16 6	2 14 3½
1902	2 17 6	2 17 6	2 15 6	2 16 9	2 16 6	2 16 6	2 16 6	2 17 0	2 18 6	2 18 6	2 17 6	2 17 6	2 17 1½
1903	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
1904	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
1905	2 13 0	2 13 0	2 11 6	2 12 6	2 12 0	2 12 0	2 12 3	2 14 0	2 16 6	2 16 6	3 0 6	3 0 6	2 14 1
1906	3 2 0	3 5 0	3 3 0	3 0 6	2 17 0	2 18 6	2 18 0	2 16 6	2 19 0	3 0 6	3 1 6	3 7 0	3 0 8½
1907	3 7 0	3 7 0	3 5 0	3 2 0	3 4 0	3 8 0	3 6 0	3 5 0	3 4 0	3 2 6	3 1 0	2 18 6	3 4 2
1908	2 15 0	2 14 6	2 14 6	2 15 6	2 14 0	2 13 0	2 13 0	2 11 6	2 12 6	2 13 0	2 12	2 12 6	2 13 5½
1909	2 13 0	2 12 6	2 11 6	2 12 0	2 12 6	2 12 6	2 12 0	2 12 6	2 14 6	2 15 0	2 14 6	2 14 0	2 13 0½
1910	2 13 9	2 14 0	2 14 0	2 14 4	2 15 0	2 15 0	2 14 9	2 15 0	2 15 0	2 15 0	2 15 0	2 15 0	2 14 7½
1911	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 14 6	2 15 0	2 15 0	2 15 8½
1912	2 17 4½	2 17 6	2 17 6	3 1 1½	3 2 6	3 3 9	3 6 3	3 7 6	3 10 10½	3 12 6	3 13 3½	3 14 6	3 5 4
1913	3 15 7	3 15 0	3 11 10½	3 11 4½	3 10 2½	3 6 10½	3 4 2½	3 2 9	3 1 9	3 1 0	3 1 6	3 5 6	3 6 5
1914	2 17 2½	2 18 0	2 18 0	2 17 0	2 16 7½	2 16 0	2 16 0	2 12 10	3 1 0	2 19 9½	2 16 11½	2 18 1½	2 18 2
1915	3 1 2	3 3 11	3 5 9	3 18 8½	3 13 7	3 14 1	3 15 0	3 13 3	3 12 0½	3 11 1	3 14 0	4 3 3	3 12 2½
1916	4 4 6½	4 11 6	4 11 6½	4 7 6	4 7 6	4 7 6	4 10 0	4 12 10	4 12 6	4 12 6	4 12 6	4 12 6	4 8 6½
1917	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6
1918	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6
1919	4 12 6	4 12 6	4 12 6	4 12 6	7 2 6	7 5 0	8 8 5	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	7 3 10
1920	9 13 9	10 0 0	10 5 3	10 15 3	11 10 0	12 2 6	12 5 0	13 1 3	14 7 6	14 5 0	14 5 0	14 5 0	12 12 1½
1921	12 11 8	10 8 9	9 2 6	8 2 0	8 0 0	8 0 0	8 0 0	8 1 8	7 4 0	6 7 6	5 7 6	4 17 10	8 0 2
1922	5 5 0	4 17 6	4 15 0	4 15 0	4 12 6	4 12 6	4 12 6	4 12 6	4 11 3	4 10 0	4 10 0	4 16 0	4 13 7½
1923	4 12 8½	5 0 2	6 2 6	6 8 7½	6 2 5	5 11 9	5 9 1½	5 4 0	5 0 0	5 0 9	5 0 7	5 2 9	5 7 11½
1924	5 3 0	5 3 0	5 3 0	5 3 0	5 2 10	5 1 3	4 17 11	4 15 6	4 13 6	4 10 1½	4 10 0	4 10 3	4 17 9½
1925	4 10 0	4 9 0	4 6 9	4 5 2½	4 3 0	4 0 1½	4 17 1½	3 15 7½	3 14 3½	3 13 4½	2 13 4½	3 13 2½	4 1 9
1926	3 14 9	3 15 3	3 15 6	3 15 3½	3 17 6	4 5 9	4 16 9	*	*	*	*	4 12 6	4 0 1½
1927	4 13 9½	4 13 3	4 11 1½	4 9 4½	4 6 1½	3 19 1½	3 16 1½	3 15 6	3 13 4½	3 13 4½	3 14 0	3 13 6½	4 1 6½
1928	3 13 2½	3 12 3½	3 12 3	3 12 3	3 11 6	3 10 0	3 8 3	3 7 8½	3 7 6	3 7 9½	3 8 3	3 7 6	3 9 10½
1929	3 8 3½	3 10 4½	3 10 10½	3 11 0	3 11 2½	3 12 0	3 12 4½	3 14 6	3 15 1½	3 17 0	3 17 0	3 17 0	3 13 1½
1930	3 17 0	3 17 0	3 17 0	3 17 0	3 17 0	3 17 0	3 15 0	3 12 0	3 12 0	3 12 0	3 10 1½	3 9 6	3 14 4½
1931	3 9 6	3 9 6	3 9 6	3 9 6	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 10
1932	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0
1933	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0
1934	3 7 0	3 9 6	3 13 2½	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 12 11½
1935	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 18 0	3 18 0	3 14 8
1936	3 18 0	3 18 0	3 18 0	3 18 0	3 18 0	3 18 0	4 3 0	4 3 0	4 3 0	4 3 0	—	—	—

* No prices available during strike period.

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

PIG IRON

REGISTERED TRADE MARK

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

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